Journal of Agricultural Science; Vol. 12, No. 4; 2020
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Impact of Zero Tillage and Tillage Practice in Chickpea Production

Md. Abdul Quddus[1], Habib Mahammad Naser[2], Md. Alamgir Siddiky[1], Md. Razzab Ali[3], A. T. M. Anwarul Islam Mondol[2] & Md. Anarul Islam[4]

[1] Soil and Water Management Section, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

[2] Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

[3] Olericulture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

[4] Pomology Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh

Correspondence: Md. Abdul Quddus, Soil and Water Management Section, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. E-mail: quddus06@yahoo.com

Received: December 31, 2019 Accepted: February 2, 2020 Online Published: March 15, 2020

doi:10.5539/jas.v12n4p106 URL: https://doi.org/10.5539/jas.v12n4p106

Abstract

The study was carried out at the field of Regional Pulses Research Station, Madaripur under Bangladesh Agricultural Research Institute (BARI) during *Rabi* season (winter) to evaluate the effect of different tillage practices on growth, yield attributes, nutrient uptake and yield of chickpea, and to compare between the zero tillage and tillage practice.The experiment was planned with five different tillage practices viz. Zero tillage (T_1), Single tillage (T_2), Two tillage (T_3), Three tillage (T_4) and Four tillage (T_5), and it was laid out in a randomized complete block design (RCBD) with three replications. Blanket dose of fertilizers of N, P, K, S, Zn and B at 20, 21, 30, 10, 3 and 1.5 kg ha^{-1}, respectively were used in all tillage treatments. The highest mean seed yield achieved (1395 kg ha^{-1}) in zero tillage (T_1) followed by four tillage (T_5) practice. The maximum number of branches plant^{-1} and more number of pods plant^{-1} was recorded in zero tillage treatment. Nutrient content showed non-significant effect across most of the treatment. The highest nodulation and nutrient (N, P, K and S) uptake was also obtained from T_1 treatment. Tillage practices exhibited positive effects on soil properties. The highest soil organic carbon, total N, available P, K, S, Ca, Mg, Zn and B were found in zero tillage (T_1). Based on profitability, the zero tillage was economically viable with compared to tillage practice. Although this practice (T_1) saves the money about 3.8% to 13.7% and time also saves minimum 8 days for succeeding crops. So, the present study suggests that zero tillage practice could be implemented in the high and medium high land for chickpea cultivation. Low income farmers may practice the zero tillage technology. Future research should be carried out to evaluate the suitable rate of nutrient in zero tillage (conservative tillage) practice for yield maximization of chickpea and sustaining soil fertility.

Keywords: zero tillage, tillage practice, chickpea yield, yield attributes, nodulation, nutrient uptake

1. Introduction

Globally the agriculture has currently been faceing enormous challenges including soil erosion which significantly reduces the yield of crops. The soil erosion by wind and related dust emission can cause substantial nutrient loss and may lead to soil degradation of fertile lands (Katra, 2020). Tillage activities can significantly accelerate wind erosion and soil loss compared with uncultivated soils or zero tillage (Sharratt et al., 2010; Singh et al., 2012). The shortage of water and increasing the price of fuel and fertilizer will increase the production costs. Increasing demand of food for the unprecedented growth of the population in recent decades has created a major challenge for researchers in the agricultural sector (Salehi et al., 2017). Chickpea (*Cicer arietinum* L.) can increase the productivity both in terms of N saving from fertilizer sources and build up soil fertility through biological source of N (Banjara et al., 2017). It can fix N up to 140 kg ha^{-1} in a growing period (Poonia and Pithia, 2013). Tillage methods affect the sustainable resources through its influence on soil properties, crop growth and the use of excessive and un-necessary tillage operations is often harmful to soil (Nazeer et al., 2012). Conservation agriculture (CA) techniques involve zero tillage which reduces the negative environmental effects of agriculture such as soil erosion and degradation of physical properties of soil leading to decrease crop productivity (Monneveux et al., 2006).

Generally, Bangladesh crop agriculture depicts excessive tillage, crop residue removal and imbalance fertilization that degraded soil health with accelerated decomposition of soil organic matter (SOM) (Salahin et al., 2019). Most agricultural soils have become vulnerable to tillage-stimulated rapid loss of SOM in the coarse texture soils (Stewart et al., 2007). Minimum or zero tillage practice to some extent increases SOM levels (Busari and Salako, 2013), enriches soil nutrients (Alam, 2018), water retention capacity (Aziz et al., 2013), and decreases the cost of production (Salahin, 2017) by reducing fuel use for intensive tillage and irrigation requirements (Johansen et al., 2012). Enormous studies conducted in home and abroad also showed that zero and minimum tillage increases SOM, microbial activity, total N, and extractable P, S, Zn and B at the soil surface to a large extent compared to conventional tillage (Alam et al., 2016; Vu et al., 2009).

Chickpea is the third most important pulse crop in the world and stands 5th in respect of area (8250 ha) and production (6488 tons yr^{-1}) in Bangladesh with an average yield of 786 kg ha^{-1} (BBS, 2016). It is grown in winter season of Bangladesh and competes with a variety of winter crops. It contains higher level of protein, fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene (Legesse et al., 2017). The acreage of chickpea cultivation in Bangladesh is decreasing day by day due to disease infestation and less return as compared to some cereal crops (*i.e.*, *Boro* rice and maize). Hence, the uses of high yielding variety (HYV) of chickpea and proper tillage practice can increase the hectare yield of chickpea. The farmers of Faridpur and Madaripur district, Bangladesh have been cultivating *T. Aman* rice in medium low lands. These areas stand under the low Ganges river floodplain soils which fertility is low to medium. After *T. Aman* rice, chickpea can easily be adopted through zero tillage practice (CA practice) in winter season.

Thus, zero tillage along with some complimentary practices has emerged as a viable option to ensure sustainable food production and maintain environmental integrity (Corsi et al., 2012). However, in Bangladesh there are very limited works on zero tillage practices for chickpea cultivation. Considering these issues, an attempt was made to identify the suitable tillage practice to reduce the vagaries of drought on growth, productivity and profitability of chickpea and save time for the successive crops in the same land.

2. Materials and Methods

2.1 Experimental Site Description

The field experiment was conducted during the *Rabi* (winter) season of 2012-13 and 2013-14 at Regional Pulses Research Station (RPRS), Madaripur (23°10′ N latitude and 90°11′ E longitude), BARI at an elevation of 7.0 m above the sea level. It belongs to the agro ecological zone, Low Ganges River Floodplain (AEZ 12). According to general soil classification, it falls under Calcareous Brown Floodplain Soils with Gopalpur soil series. Beginning the experiment, initial soil sample was collected at 0-15 cm depth from different spots of the experimental field and analysed. The morphological, taxonomical and physical characteristics are shown in Table 1. The chemical properties are presented in Table 2.

Table 1. Morphological, taxonomical and physical characteristics of the experimental field

Characteristics	RPRS farm, Madaripur		
Agro-Ecological Zone (UNDP, 1988)	Low Ganges River Floodplain (AEZ 12)		
General soil type	Calcareous Brown Floodplain Soil		
Taxonomic soil classification		Physical properties of soil	Values
Order	Inceptisols	% Sand	30.72
Sub order	Ochrepts	% Silt	44.00
Great group	Eutrochrepts	% Clay	25.28
Sub-group	Aquic Eutrochrepts	Textural class	Loam
Soil series	Gopalpur	Particle density (g cm^{-3})	2.60
Parent material	Gangetic alluvium	Bulk density (g cm^{-3})	1.39
Topography	Level	Porosity (%)	46.54
Drainage situation	Moderate	Hydraulic conductivity (cm sec^{-1})	2.14×10^{-5}
Flood level	Above flood level		
Geographic position	23°10′ N latitude and 90°11′ E longitude, 7.0 m above sea level		
Land type	High land		

Table 2. Chemical properties of initial soil of the experimental field

Location	pH	Previous crop	OC	Total N	Ca	Mg	K	P	S	Zn	B
			------ g kg^{-1} ------		---- meq. 100 g^{-1} ----			-------------------- mg kg^{-1} -------------------			
Madaripur (result)	7.4		8.38	0.65	13.1	5.15	0.16	16	18.3	1.10	0.16
Critical level	-	*T. aman* rice	-	1.2	2.0	0.50	0.12	10	10	0.60	0.20
*Interpretation	slightly alkaline		low	very low	high	high	low	medium	medium	medium	low

Note. * Bangladesh Agricultural Research Council (2012).

The climate of the experimental site is sub-tropical humid monsoon condition. It is characterized by comparatively monsoon rainfall, high humidity, and high temperature during March to June. Long day with less clear sunshine, sometimes the sky remains cloudy for heavy rainfall (about 80% of the total rainfall) during June to October. The scanty rainfall, low humidity, and low temperature, short day and more clear sunshine during October to March. Average temperature ranged from 13.0 to 38 °C and average annual rainfall varied from 1500 to 5500 mm around the year (Huq and Shoaib, 2013). The rainfall ganged from 7.6 to 80.2 mm during the period of the experiment. The mean minimum and maximum air temperature during this period was 10.3 and 34.8 °C, respectively.

2.2 Experimental Design, Treatment and Layout

The experiment was laid out in a randomized complete block design (RCBD) with three replicates and consisted of five tillage practices such as T_1 (Zero tillage-soil was undisturbed, but furrow was prepared by manually made single tine for seed sowing), T_2 (Single tillage-tilled one pass of power tiller machine followed by 1 laddering), T_3 (Two tillage-tilled two passes of power tiller machine followed by 2 laddering), T_4 (Three tillage-tilled three passes of power tiller machine followed by 2-3 laddering) and T_5 (Four tillage-tilled four passes of power tiller machine followed by 2-3 laddering). The depth range of tillage practices were maintained by 6 to 12 cm. The unit plot size was 5 m × 4 m with the spacing of 50 cm × 10 cm.

2.3 Agronomic Management

In the experiment, the soils for zero tillage was remain undisturbed during the period of rice harvest for sowing chickpea. However, the *T. Aman* rice was harvested retaining about 15 cm straw in the study plot. The test crop variety was BARI Chola-9. Chickpea seeds at 40 kg ha^{-1} were sown in the plot of zero tillage in furrow continuously about 4-5 cm depth maintaining row to row distance 50 cm on 03 November 2012 and 04 November 2013. Fertilizers of N, P, K, S, Zn, and B at 20, 21, 30, 10, 3 and 1.5 kg ha^{-1} respectively were applied after one day of rice harvesting in the zero tillage plot. On the other hand, whole amount of fertilizers of N, P, K, S, Zn and B at 20, 21, 30, 10, 3 and 1.5 kg ha^{-1} respectively were used in all the plot of tillage treatments. The sources of N, P, K, S, Zn and B, respectively were urea, TSP, MoP, gypsum, zinc sulphate and boric acid. The seed rate of 40 kg ha^{-1} was also sown in all tillage plots continously maintaining row to row distance 50 cm on 13 November 2012 and 14 November 2013. Three hand weedings were completed for zero tillage at 15, 30 and 50 days after sowing. On the other hand, two hand weedings were done for all plots of tillage practices at 25 and 50 days after sowing. The disease (BGM) influx was managed by spraying the fungicide Secure 600 wg at 0.2% two times at an interval of 10 days start at flowering stage. The insect (pod borer and aphid) infestation was controlled by spraying Karate at 0.2% two times at 10 day intervals during podding stage. Irrigation was not applied. The test crop was harvested at maturity. Crop of zero tillage was harvested on 4 March 2013 and 3 March 2014 and the crop of tillage practices (single, two, three and four tillage) was harvested on 11 March 2013 and 12 March 2014. Maturity refers that chickpea pods to be brown or yellow brown coloured and seed become hard having 12 to16% moisture.

2.4 Data Collection

In the experiment, the nodules per plant were counted at 60 days after sowing (DAS) in each treatment plot by selecting 5 plants randomly. The chickpea plants were simply uprooted with the help of Khurpi and the roots were washed carefully by clean water. Then the roots were blotted with tissue paper. The number of nodules per plant was counted and averaged. Mature ten plants of chickpea were randomly selected and uprooted from each treatment plot. Plot wise from these ten plants, the data of plant height, number of branches per plant, pods per plant, respectively were recorded. Plant height was recorded from above ground part and averaged. Primary branches per plant was counted and averaged. Pods were detached from every plant and the number of pods per plant was counted and averaged. Ten pods were separated randomly from composite pods of 10 plants from each plot. The number of seeds per pod was counted from ten pods and averaged. For stover yield (kg ha^{-1}), mature plants were collected instead of border row from 1-m^2 in each plot at harvest time. The harvested plants were sun dried and seeds were separated. The dry straws were weighed and the weight was converted to kg ha^{-1}. For seed yied, total dried seed (9% moisture) of each treatment plot (5 m × 4 m) was weighed and converted it to kg ha^{-1}.

The 100-seed weight (g) was determined by randomly counting of 100-seed from the whole seeds of each plot and weighed. Percentage of harvest index (HI) was determined by the formula,

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \quad (1)$$

2.5 Soil Samples Collection, Preparation and Analysis

Before stating the experiment, soil samples of the experimental area was collected (0-15 cm depth) from five spot with auger and mixed together thoroughly to make a composite sample which was brought to the laboratory. It was air dried and ground to pass through 20 mesh sieve. Postharvest soil samples of the experimental plot were collected from 0-15 cm depth. The combined soil sample of each plot was brought to the laboratory and spread on a brown paper for air drying. The air-dried soil samples were ground and passed through a 20-mesh sieve. After sieving, the prepared soil samples were kept into plastic containers with proper label for physical and chemical analysis.

2.5.1 Methods of Physical Properties Analysis

Textural analysis of soils was done by hydrometer method (Bouyoucos, 1962) and the textural class was determined from Marshall's triangular co-ordinate following USDA system. Particle density was determined by volumetric flask method (Black, 1965) using the formula mentioned below.

$$\text{Particle density (Dp)} = \frac{M_s}{V_s}\ (\text{g cm}^{-3}) \quad (2)$$

Where, D_P = Particle density (g cm^{-3}), Vs = Volume of soil solid (cm^{-3}), Ms = Weight of soil solid (g). Bulk density was determined by core sampler method (Black, 1965) using the following formula.

$$\text{Bulk density (Db)} = \frac{M_s}{Vt}\ (\text{g cm}^{-3}) \quad (3)$$

Where, Db = Bulk density (g cm^{-3}), Ms = Mass of soil solid (g), Vt = Total volume of soil (cm^{-3}). Soil porosity was calculated from the results of particle density and bulk density with the following formula.

$$\text{Soil porosity} = \frac{D_p - D_b}{D_p} \times 100 \quad (4)$$

Where, Dp = Particle density (g cm^{-3}), Db = Bulk density (g cm^{-3}). Saturated hydraulic conductivity was determined by constant head method (Klute, 1965) from eight experimental sites. Samples were collected from 0-15 cm depth using core samplers in triplicate. The hydraulic conductivity was calculated by using Darcy's equation as follows:

$$K = -\frac{OL}{AT\Delta H}\ (\text{cm hr}^{-1}) \quad (5)$$

Where, K = Saturated hydraulic conductivity (cm hr^{-1}), A = Cross sectional area of the sample in cm^2, T = Time in minute, Q = Quantity of water (ml) passing through the sample in time 'T', L = Length of the sample in cm, ΔH = Hydraulic head difference (Length of sample + height of water above the sample) in cm.

2.5.2 Methods of Chemical Properties Analysis

Soil pH was measured by glass electrode pH meter using soil: water ratio of 1:2.5 Page et al. (1982). Organic carbon was determined following the wet oxidation method as described by Page et al. (1982). Total N content was determined following micro Kjeldhal method (Bremmer and Mulvaney, 1982). Available P by Olsen method as described by Page et al. (1982) and available S were determined by extracting the soil sample with 0.15% $CaCl_2$ solution as described by Page et al. (1982). The reading was taken using UV visible Spectrophotometer (Varian Model 50 Conc.) at 720 nm and 420 nm wavelength for P and S, respectively. Exchangeable K, Ca and Mg were extracted with 1 M NH4OAc solution (pH = 7) (Thomas, 1982). For exchangeable K, the reading was taken directly using AAS (Chemito AA 203) at 766.5 nm wavelength. For Ca, 2 ml aliquot was diluted with 1 ml of La_2O_3 and 7 ml of distilled water and then reading was taken using AAS (Chemito AA 203). In case of Mg, 1 ml aliquot was diluted with 9 ml of distilled water and reading was taken using the same AAS. Available Zn was determined by DTPA method (Lindsay and Norvell, 1978); available B by azomethine-H method Page et al., (1982).

2.6 Plant Sample Analysis

Ground straw and seed samples were digested with di-acid mixture (HNO_3-$HClO_4$) (5: 1) as described by Piper (1964) for the determination- concentration of N (Micro-Kjeldahl method), P (spectrophotometer method), K (atomic absorption spectrophotometer method) and S (turbidity method using $BaCl_2$ by spectrophotometer).

2.7 Nutrient Uptake Determination

Nutrient (N, P, K, S, Zn and B) uptake by the test crop was calculated from the results of crop yield and nutrient content in seed and straw (FRG, 2012).

2.8 Statistical Analysis

The experiment was conducted two years following a randomized complete block design (RCBD) with three replications. Analysis of variance was performed following RCB design. The average of two years data of nutrient (N, P, K and S) content and data of nutrient uptake were used for statistical analysis. All data obtained from the experiments were analyzed by statistical software Statistix-10 (Statistix-10, 1985). The means of all data were compared using the least significant difference (LSD) test at a significant level of $p \leq 0.05$.

2.9 Partial Budget Analysis

Benefit cost ratio (BCR) refers to the ratio of gross return and the total variable cost of production of any project in monetary term. Higher BCR expresses higher return from the production and vice-versa. BCR was determined (Tithi and Barmon, 2018) by the formula,

$$\text{BCR} = \frac{\text{GR}}{\text{VC}} \tag{6}$$

BCR was counted for a hectare of land. Treatment wise management cost was calculated by adding the cost incurred for labours, ploughing and inputs for each treatment. The seed yield was converted into kg ha^{-1}. This yield was used to calculate the gross return. The shadow prices of land rent and straw cost were not considerd in this study. The gross return was measured by multiplying the seed yield by the present unit price of chickpea. Gross margin was calculated by subtracting management cost from gross return.

3. Results and Discussion

3.1 Growth and Yield Attributes of Chickpea

Growth and yield attributes of chickpea showed significant variation due to different tillage practices except 100-seed weight that was non-significant (Tables 3 and 4). Significantly tallest plant (48.9 cm in 1st year and 50.1 cm in 2nd year) was observed in zero tillage (T_1) treatment as compared to the rest of treatments, however, it was found statistically similar to treatment T_5 in both the years but at par T_3 at 1st year and T_4 at 2nd year. The mean plant height of chickpea varied from 42.2 to 49.5 cm across the treatments, while the dwarf plant (42.2 cm) was recorded from T_2 treatment (Table 3). The tallest plant in T_1 treatment might be indicated as keeping optimum moisture in soil for available nutrients to plant uptake. This observation is partially in agreement with the findings of Banjara et al. (2017) who reported that zero tillage and minimum tillage both were showed statistically similar result on plant height of chickpea. The maximum number of branches per plant (4.78 at 1st year and 4.29 at 2nd year) was obtained by zero tillage (T_1) followed by four tillage practice (T_5) and the minimum branches per plant were obtained from single tillage (T_2) treatment. The mean (average of two years) branches per plant were ranged from 3.65 to 4.54 across the treatments (Table 3). Soil physical properties were might be more favourable in zero tillage than tillage-based systems. It was found that zero tillage significantly improved saturated and unsaturated hydraulic conductivity owing to either continuity of pores or flow of water through very few large pores (Lal, 1997; Allmaras et al., 1977; Benjamin, 1993). However, zero tillage contributed to get higher number of branches $plant^{-1}$. In this experiment, the highest number of pods per plant (56.6 at 1st year and 57.2 at 2nd year) was recorded from the treatment T_1 which was showed significant different to other treatments, but statistically identical to T_5, T_4 and T_3 treatments. The mean number of pods per plant was varied among the treatments from 49.9 to 56.9, while the highest pods per plant was attained in zero tillage (T_1) and lowest was in single tillage (T_2) (Table 3). Number of pods per plant is most prominent yield trait and, is much closed to obtain higher yield. The highest number of pods $plant^{-1}$ was achieved in zero tillage (T_1) which is related with more branching. The climatic condition of zero tillage plots might be favoured to growth and development of chickpea plant. Busari et al. (2015) reported that zero (no-till) tillage system successfully adopts the weather conditions in the growing season. According to an FAO (2012) report, climate adaptation benefits of no-tillage can be significant. As a result, the higher number of pods per plant was acquired in zero tillage than tillage practice.

Table 3. Effect of different tillage practices on plant height, number of branches plant^{-1} and number of pods plant^{-1} of chickpea

Treatment	Plant height (cm)			No. of branches plant^{-1}			No. of pods plant^{-1}		
	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean
T_1 (Zero tillage)	48.9a	50.1a	49.5	4.78a	4.29a	4.54	56.6a	57.2a	56.9
T_2 (Single tillage)	42.6c	41.8b	42.2	3.52b	3.77b	3.65	50.1b	49.7b	49.9
T_3 (Two tillage)	46.7ab	43.6b	45.2	4.12ab	3.93b	4.03	53.9ab	54.6a	53.7
T_4 (Three tillage)	44.3bc	47.9a	46.1	3.97ab	3.80b	3.89	52.8ab	53.5ab	53.2
T_5 (Four tillage)	47.4a	48.6a	48.0	4.38ab	4.25a	4.32	54.8a	56.3a	55.6
CV (%)	3.55	3.74	-	13.1	3.85	-	4.07	3.95	-
$LSD_{0.05}$	3.07	3.27	-	1.03	0.29	-	4.11	4.04	-

Note. In a column, the values having common letter do not differ significantly ($P \leq 0.05$).

In the case of number of seeds pod^{-1}, the maximum number of seeds per pod of chickpea (1.35 at 1st year and 1.39 at 2nd year) was recorded significantly from zero tillage (T_1) followed by four tillage treatment (T_5). The mean number of seeds per pod was ranged from 1.24 to 1.37 across the treatments however; the maximum seeds pod^{-1} (1.37) was found in T_1 and minimum (1.24) was in single tillage (T_2) treatment (Table 4). Banjara et al. (2017) also reported that the highest number of seeds per pod (1.27) was oberved in both zero tillage and minimum tillage practice. The seed weight of chickpea was exhibited non-significant across the treatments in both the study years. It is noted that seed weight is a vital quality attribute of any crop. But this character might be genetically controlled in same variety; hence the growing condition is not significantly influenced on its expression. In this experiment, the mean 100-seed weight varied from 19.3 to 20.4 g across the tillage practices, where the highest 100-seed weight (20.4 g) was obtained from the T_1 treatment and the lowest (19.3 g) was from T_2 treatment (Table 4). The nodulation of chickpea was significantly influenced by different tillage practices (Table 4). The pooled number of nodules per plant was varied from 18.0 to 22.1 across the treatments. The highest number of root nodules plant^{-1} (21.6 at 1st year and 22.6 at 2nd year) was obtained from zero tillage (T_1) which was significantly different over the other treatment but statistically identical with T_5 treatment in both the years. The lowest (18.0) nodulation (pooled data) of chickpea was found in single tillage (T_2) practice (Table 4). The prominent result of nodulation by zero tillage might be conserved moisture; improved fertility associated with minimum disturbance of soil and makes more efficient use of natural resources as well as nutrient (FAO, 2001; Bell et al., 2019). Hence, the zero tillage contributed to achieve higher root nodules.

Table 4. Effect of different tillage practices on number of seeds pod^{-1}, 100-seed weight and number of nodules plant^{-1} of chickpea

Treatment	No. of seeds pod^{-1}			100-seed weight (g)			No. of nodules plant^{-1}		
	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean
T_1 (Zero tillage)	1.35a	1.39a	1.37	19.7a	21.1a	20.4	21.6a	22.6a	22.1
T_2 (Single tillage)	1.22b	1.26bc	1.24	18.5a	20.0a	19.3	17.3b	18.7bc	18.0
T_3 (Two tillage)	1.30ab	1.22c	1.26	19.0a	20.4a	19.7	18.3b	17.9c	18.1
T_4 (Three tillage)	1.31ab	1.30b	1.31	18.9a	20.7a	19.8	17.4b	19.4bc	18.4
T_5 (Four tillage)	1.33ab	1.36a	1.35	19.2a	20.9a	20.1	19.8ab	21.3ab	20.6
CV (%)	5.01	2.40	-	4.16	4.18	-	7.82	7.48	-
$LSD_{0.05}$	0.12	0.06	-	ns	ns	-	2.78	2.81	-

Note. In a column, the values having common letter do not differ significantly ($P \leq 0.05$).

3.2 Yields of Chickpea

The chickpea seed yield was significantly influenced ($P \leq 0.05$) by different tillage practices in both the years. The highest seed yield (1355 kg ha^{-1} at 1st year and 1434 kg ha^{-1} at 2nd year) was found in zero tillage (T_1) followed by four tillage (T_5) (1224 kg ha^{-1} at 1st year and 1269 kg ha^{-1} at 2nd year). The lowest seed yield was obtained in single tillage (T_2) in both the years which was significantly inferior to another tillage practices. The mean seed yield of chickpea was ranged from 906 to 1395 kg ha^{-1} across the treatments (Table 5). In the study, significantly highest straw yield of chickpea in both the years was obtained from T_1 treatment. Hence, the mean straw yield of chickpea varied from 1577 to 2098 kg ha^{-1} across the different tillage practices, while the highest straw yield (2098 kg ha^{-1}) was recorded from T_1 treatment (Table 5). The higher yields of chickpea might be achieved by the more number of branches plant^{-1} and more number of pods plant^{-1}. Similar observation was noted by Banjara et al. (2017). Bimbraw (2016) reported that chickpea showed better performance in the zero tillage and minimum tillage by placing the seed at proper depth and soil moisture, which resulted in better yield in chickpea. Zero tillage plays a significant role in root mass density distribution in the soil. However, deep tillage obstructed root proliferation by the dense or compact layer of the soil profile (Hassan et al., 2005) which ultimately reduced the yield of chickpea. Bandyopadhyay (2012) observed that root diameter and root mass density of lentil in zero tillage system is increased compared to conventional tillage. Zero tillage might be facilitated to increase organic matter and microbial activities in soil whatever improvement of chickpea yields. Similar opinion made by Peigné et al. (2007) that zero tillage (ZT) practice enhanced microbial activity and C sequestration, reduce nutrient leaching and erosion. Alam et al. (2014) reported that zero tillage significantly increased the soil organic matter in 0-25 cm soil layer compared to deep tillage. In the present study, the harvest index (HI) exhibited significant variation across the different tillage practices during 1st year and 2nd year (Table 5). The highest harvest index (39.9% at 1st year and 40.0% at 2nd year) was recorded from zero tillage (T_1) which was significantly different over the other treatment but statistically alike with T_3, T_4 & T_5 treatments at 1st year and alike with T_4 & T_5 treatments in 2nd year. The mean harvest index data among the different tillage practices were varied from 36.4 to 40.0% however, the highest HI% was found in T_1 followed by T_4 treatment and the lowest (36.4%) HI was achieved in T_2 treatment (Table 5). Similar result was noted by Banjara et al. (2017) that the highest harvest index (39.70%) of chickpea was recorded in zero tillage.

Table 5. Effect of different tillage practices on seed yield, straw yield and harvest index of chickpea

Treatment	Seed yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean	1st yr.	2nd yr.	Mean
T_1 (Zero tillage)	1355a	1434a	1395	2049a	2147a	2098	39.9a	40.0a	40.0
T_2 (Single tillage)	956c	855c	906	1612b	1542c	1577	37.1b	35.6c	36.4
T_3 (Two tillage)	1156abc	1017bc	1087	1800ab	1688bc	1744	39.0ab	37.6b	38.3
T_4 (Three tillage)	1103bc	1200ab	1152	1788ab	1814abc	1801	38.2ab	39.9a	39.1
T_5 (Four tillage)	1224ab	1269a	1247	1987ab	2025ab	2006	38.2ab	38.6ab	38.4
CV (%)	10.1	10.9	-	11.7	10.2	-	2.73	2.13	-
$LSD_{0.05}$	219	239	-	407	355	-	1.97	1.54	-

Note. In a column, the values having common letter do not differ significantly ($P \le 0.05$).

3.3 Effects of Tillage Practices on N, P, K and S Content of Chickpea

In the present experiment, different tillage practices had no significant contribution to the N and S content in seed of chickpea, but showed significant influence to P and K content. The results of P, K and S content in straw of chickpea were affected non-significantly by the different tillage practices. On the other hand, N content in straw was displayed significantly different due to tillage practices (Table 6). The highest N content in seed (33.9 g kg^{-1}) was obtained from the T_1 treatment; however the lowest N (32.3 g kg^{-1}) content was noted in T_4 treatment. In the case of N content in straw, the highest N content (16.9 g kg^{-1}) was recorded from T_4 treatment which was statistically similar to T_5, T_3 and T_1 treatments (Tables 6). In the study, the highest P content (6.53 g kg^{-1}) in seed of chickpea was achieved in the T_3 treatment, which was statistically comparable with T_5, T_4 and T_1 treatments and the lowest P content (5.58 g kg^{-1}) was found in T_2 treatment. Concerning K content, the highest K content in seed of chickpea (16.4 g kg^{-1}) was recorded from T_5 treatment which was statistically at par with T_4, T_3 and T_1 treatments and the lowest K content (15.2 g kg^{-1}) was in T_2 treatment. The K content in straw of chickpea was showed non-sgnificant across the different tillage practices. The highest amount of S (0.99 g kg^{-1}) in seed was got from T_4 treatment and the highest S content (1.29 g kg^{-1}) in straw was obtained from T_1 treatment, both were not statistically similar to any other treatment (Table 6). Hargrove (1985) reported that the nutrient status in plants which grown under no-tillage management was superior to those grown by conventional tillage.

Table 6. Effect of different tillage practices on nutrients content in seed and straw of chickpea (pooled data of two years)

Treatment	N	P	K	S
	------------- g kg^{-1} -------------			
Seed				
T_1 (Zero tillage)	33.9a	5.67ab	15.9ab	0.97a
T_2 (Single tillage)	33.3a	5.58b	15.2b	0.93a
T_3 (Two tillage)	32.4a	6.53a	15.7ab	0.98a
T_4 (Three tillage)	32.3a	6.50ab	16.0ab	0.99a
T_5 (Four tillage)	33.8a	6.21ab	16.4a	0.96a
CV (%)	4.55	8.23	4.84	4.87
$LSD_{0.05}$	ns	0.94	1.44	ns
Straw				
T_1 (Zero tillage)	16.3ab	1.78a	25.6a	1.29a
T_2 (Single tillage)	15.8b	1.73a	24.9a	1.26a
T_3 (Two tillage)	16.6ab	1.74a	25.0a	1.18a
T_4 (Three tillage)	16.9a	1.80a	25.5a	1.28a
T_5 (Four tillage)	16.6ab	1.79a	25.6a	1.26a
CV (%)	2.74	3.84	4.74	4.64
$LSD_{0.05}$	0.85	ns	ns	ns

Note. In a column, the values having common letter do not differ significantly ($P \leq 0.05$).

3.4 Effects of Tillage Practices on N, P, K and S Uptake by Chickpea

The uptake of N, P, K and S by chickpea seed was remarkably influenced by different tillage practices (Tables 7). The uptake of nutrients by seed of chickpea was ranged from 30.1 to 47.3 kg N ha^{-1}, 5.06 to 7.90 kg P ha^{-1}, 13.8 to 22.2 kg K ha^{-1} and 0.84 to 1.35 kg S ha^{-1} across the treatments. The highest uptake of N (47.3 kg ha^{-1}) was recorded from the T_1 treatment which was significantly different with other treatments and the lowest uptake of N (30.1 kg ha^{-1}) was observed in T_2 treatment. In this study, the highest uptake of P (7.90 kg ha^{-1}) by seed was noted in T_1 treatment that was statistically similar to the treatments of T_5, T_4 and T_3, however the lowest uptake of P was found in T_2 treatment. In the case of K and S uptake, the highest uptake of K (22.2 kg ha^{-1}) and S (1.35 kg ha^{-1}) was obtained from the T_1 treatment (Table 7). Different tillage practices showed significant effect on the uptake of N, P, K and S by chickpea straw (Table 7). In this experiment, the highest uptake of N (33.4 kg ha^{-1}) was occurred in the T_5 treatment which was significantly different over the other treatments, but statistically identical with T_1 and T_4 treatments, while the lowest uptake of N amount (24.9 kg ha^{-1}) was found in T_2 treatment. Regarding P uptake by straw of chickpea, the uptake of P was ranged from 2.72 to 3.59 kg ha^{-1}across the treatment. The uptake of P by straw is showed similar trend to the N uptake by straw. In the case of K and S uptake by straw, the maximum uptake of K (53.6 kg ha^{-1}) and S (2.71 kg ha^{-1}) was recorded from the T_1 treatment which treatment was significantly different with other treatment but statistically at par T_5 treatment, however the lowest uptake of K (39.3 kg ha^{-1}) and S (1.99 kg ha^{-1}) was noted in T_2 treatment (Table 7). Roy et al. (2014) reported that chickpea sown without seed bed preparation with Pantnagar zero till drill showed the highest NPK uptake as compared to other methods.

Table 7. Effect of different tillage practices on nutrients uptake by chickpea (Pooled data of two years)

Treatment	N	P	K	S
	kg ha^{-1}			
Seed				
T_1 (Zero tillage)	47.3a	7.90a	22.2a	1.35a
T_2 (Single tillage)	30.1d	5.06b	13.8c	0.84d
T_3 (Two tillage)	35.2c	7.10a	17.1b	1.07c
T_4 (Three tillage)	37.2c	7.49a	18.5b	1.14bc
T_5 (Four tillage)	42.1b	7.74a	20.5a	1.20b
CV (%)	2.81	8.96	5.45	4.12
$LSD_{0.05}$	2.03	1.19	1.89	0.09
Straw				
T_1 (Zero tillage)	31.4ab	3.42ab	53.6a	2.71a
T_2 (Single tillage)	24.9c	2.72c	39.3c	1.99d
T_3 (Two tillage)	28.9bc	3.04bc	43.6b	2.07cd
T_4 (Three tillage)	30.5ab	3.24ab	45.8b	2.30bc
T_5 (Four tillage)	33.4a	3.59a	51.1a	2.52ab
CV (%)	7.59	8.03	4.85	5.61
$LSD_{0.05}$	4.26	0.48	4.27	0.24

Note. In a column, the values having common letter do not differ significantly ($P \leq 0.05$).

In this study, the highest total uptake of N (78.7 kg ha^{-1}) by chickpea (seed + straw) was achieved in T_1 treatment and the lowest (55.0 kg ha^{-1}) was in T_2 treatment (Figure 2). In the case of P uptake, the maximum total P uptake was recorded (11.3 kg P ha^{-1}) from the treatments T_1 and T_5 (Figure 2). Regarding K and S uptake, the highest total K uptake was obtained (75.8 kg K ha^{-1}) from the treatments T_1 and the highest total S uptake (4.06 kg ha^{-1}) was also obtained from the same treatment (Figure 2). The above N, P, K and S uptake variation among the different tillage practices migh be governed by the chickpea yield.

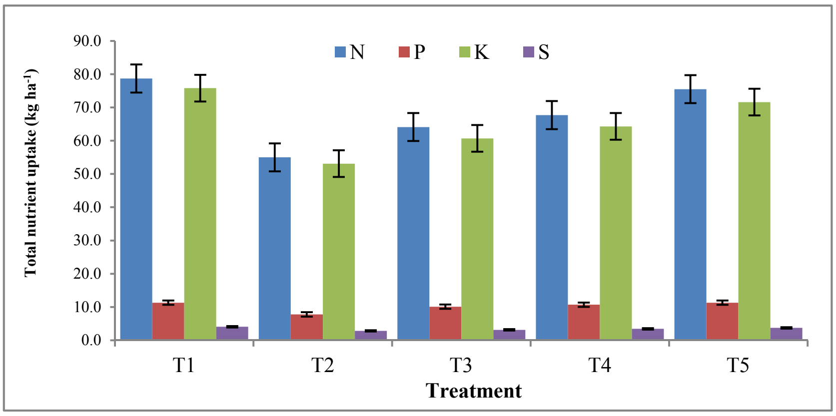

Figure 2. Effect of different tillage practices on total nutrients uptake by chickpea (seed + straw)

Note. T_1 (Zero tillage), T_2 (Single tillage), T_3 (Two tillage), T_4 (Three tillage) and T_5 (Four tillage). Error bars represent the SEM.

3.5 Effect of Different Tillage Practices on Postharvest Soil Properties

Different tillage practices contributed positive impact on postharvest soil properties. In the experiment, the pH of postharvest soils decreased slightly in all the tillage practices as compared to the initial value (Table 8). The pH of postharvest soil showed significant variation across the treatments. The decreasing percentage value of pH was highest (2.70%) in zero tillage (T_1) followed by the four tillage (T_5) and the lowest decrease of pH (1.35%) were observed in others treatments as compared to initial pH value. The organic carbon (OC) of intial soil was 8.38 g kg^{-1}; however tillage practices were exhibited significant change in postharvest soil (Table 8). The highest OC (8.90 g kg^{-1}) was recorded from zero tillage (T_1) which was significantly different with the other treatment, but statistically identical with four tillages (T_5) and the lowest was in single tillage (T_2). Bhattacharryya et al. (2008) noted that conservation tillage (zero tillage) system generally improve the soil organic C (SOC). Different tillage practices have a tendency to maintain the initial fertility or increased slightly of soil organic carbon, total

N, available P, S, Zn and B except exchangeable K, Ca and Mg that's were static or slightly decreased. In this study, most of the nutrient showed significantly variation among the tillage practices. The significantly highest N (0.75 g kg^{-1}) in soil was found for zero tillage (T_1) and lowest (0.70 g kg^{-1}) was in single tillage (T_2). Alam et al. (2014) reported that organic matter and total N was observed highest in zero tillage under wheat-mungbean *T. aman* cropping system. In most of the cases, P, K, S, Ca, Mg, Zn and B contents were showed significanly higher in zero tillage (T_1). Zero tillage might be favoured to the soil microbial activities and biological properties improvement; those are ultimately increased soil fertility. Busari et al. (2015) noted similar statement. Ismail et al. (1994) and Rahman et al. (2008) reported that exchangeable Ca, Mg, and K, were significantly higher in the surface soil under NT (no-tillage) compared to the ploughed soil.

Table 8. Effect of different tillage practices on postharvest soil pH and the status of different nutrients (mean of two years) with reference to initial soil

Treatment	pH	OC	Total N	Ca	Mg	K	P	S	Zn	B
		-------- g kg^{-1} --------		--------- meq. 100 g^{-1} --------			------------------- mg kg^{-1} -------------------			
Initial	7.4	8.38	0.65	13.1	5.15	0.16	16.0	18.3	1.10	0.16
T_1 (Zero tillage)	7.2b	8.90a	0.75a	12.9a	5.10a	0.16a	16.5a	18.6a	1.17a	0.18a
T_2 (Single tillage)	7.3a	8.61c	0.70d	12.8a	5.03b	0.14c	16.4ab	18.5ab	1.16ab	0.17b
T_3 (Two tillage)	7.3a	8.67bc	0.71cd	12.6b	5.00c	0.14c	16.4ab	18.4b	1.15b	0.16c
T_4 (Three tillage)	7.3a	8.73b	0.72bc	12.4c	4.92e	0.14c	16.4ab	18.4b	1.15b	0.16c
T_5 (Four tillage)	7.2b	8.84a	0.73b	12.1d	4.96d	0.15b	16.3b	18.5ab	1.16ab	0.17b
CV (%)	0.08	0.59	1.24	0.71	0.18	0.61	0.55	0.48	0.86	0.53

Note. Values within the same column with a common letter do not differ significantly ($P \leq 0.05$).

3.6 Economic Analysis

Different tillage practices contributed to make variation in the cost of cultivation, gross return, gross margin and benefit cost ratio (Table 9). The highest cost of cultivation (Tk. 41082 ha^{-1}) was incurred in treatment T_5 followed by treatments T_4, T_3 and T_2. However the lowest (Tk. 35482 ha^{-1}) cultivation cost was incurred in zero tillage (T_1) practice. The present experiment is also indicated that zero tillage practice might be cost effective since it saved production cost by 3.8%, 7.3%, 10.6% and 13.7% compared to single tillage (T_2), two tillages (T_3), three tillages (T_4) and four tillages (T_5), respectively. In this experiment, the maximum gross return (Tk. 83700 ha^{-1}) and gross margin (Tk. 48218 ha^{-1}) were noted from T_1 treatment followed by T_5, T_4 and T_3. The minimum gross return (Tk. 54360 ha^{-1}) and gross margin (Tk. 17478 ha^{-1}) was recorded in one-tillage (T_2) treatment due to lower yield of chickpea. Similarly, the highest benefit cost ratio (BCR) 2.36 was counted from T_1 followed by T_5 and T_4 treatment and the lowest BCR (1.47) was from one-tillage (T_2) treatment (Table 9). Similar results were observed by Banjara et al. (2017) in chickpea that recorded the highest BCR (2.96) in zero tillage. Prasad et al. (2002) reported that during the two-year of study, zero tillage with the yields of 46.88 and 35.27 q ha^{-1} out yielded as compared to conventional tillage with the yield of 37.18 and 30.75 q ha^{-1} with markedly better net returns, benefit cost ratio and advancing sowing by 20 days.

Table 9. Effect of different tillage practices on the profitability of chickpea cultivation (Pooled data of two years)

Treatment	Seed yield	Gross return	Variable cost	Gross margin	BCR
	kg ha^{-1}	--------------------------- Tk. ha^{-1} -----------------------------			
T_1 (Zero tillage)	1395	83700	35482	48218	2.36
T_2 (Single tillage)	906	54360	36882	17478	1.47
T_3 (Two tillage)	1087	65220	38282	26938	1.70
T_4 (Three tillage)	1152	69120	39682	29438	1.74
T_5 (Four tillage)	1247	74820	41082	33738	1.82

Note. Input prices: Urea = Tk. 16 kg^{-1}, T.S.P. = Tk. 22 kg^{-1}, MoP = Tk. 17 kg^{-1}, Gypsum = Tk. 12 kg^{-1}, Zinc sulphate = Tk. 160 kg^{-1}, Boric acid = Tk. 155 kg^{-1}, Secure 600 wg = Tk. 200 100^{-g}, Karate = Tk. 450 500^{-ml}, Chickpea seed = Tk. 80 kg^{-1}, Plowing = Tk. 1400 ha^{-1}(one pass), Wage rate = Tk. 300 day^{-1}. Output price: Chickpea seed at TK. 60 kg^{-1}.

4. Summary and Conclusions

The experiment has generated significant information on tillage practices to upscale the unit yield of chickpea and rising coverage of its cultivation. The tillage experiment indicates appreciably that zero tillage contributes to attain more branches and setting more pods per plant which finally augments the seed yield. Results reveal that the highest seed yield of chickpea (1395 kg ha^{-1}) has been achieved in zero tillage followed by the practice of four tillages (T_5). Harvest index is also highest in zero tillage (T_1). In this experiment, zero tillage practice has an effective tendency to obtain the maximum number of nodules per plant. Nutrient content shows non-significant effect across most of the treatments.The highest nutrient (N, P, K and S) uptake also obtains from T_1 treatment.The soil fertility is positively improved due to zero tillage followed by four tillages. The highest soil organic carbon, total N, available P, S, Ca, Mg, Zn and B are recorded in zero tillage (T_1). The organic carbon, total N, available P, S, Zn and B content in postharvest soils of all tillage practices are higher than the initial soil except K, Ca and Mg content. The zero tillage practice is more profitable than that of other tillage practices. Farmers can save ploughing cost ranged from 3.8% to 13.7% and time (minimum 8 days) by practicing zero tillage for succeeding crops. So, the present study suggests that zero tillage practice could be implemented in the high and medium high land for chickpea production. Future research may be carried out to evaluate the suitable rate of nutrients in zero tillage (conservative tillage) practice for yield maximization of chickpea and sustaining soil fertility.

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