PERFORMANCE OF LENTIL UNDER RICE RESIDUE RETENTION AND TILLAGE AS A CLIMATE CHANGE ADAPTATION TECHNOLOGY

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CERTIFICATE

*This is to certify that the thesis entitled "***PERFORMANCE OF LENTIL UNDER RICE RESIDUE RETENTION AND TILLAGE AS A CLIMATE CHANGE ADAPTATION TECHNOLOGY***"submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGROFORESTRY AND ENVIRONMENTAL SCIENCE****, embodies the results of a piece of bona fide research work carried out by* **ASMA AKTER***, Registration No.***11-04287***under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: December, 2017

Place: Dhaka, Bangladesh

[redacted]

Prof. Dr. Nazmun Naher
Supervisor

DEDICATED TO MY

BELOVED PARENTS

&

TEACHER

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ABSTRACT

Bangladesh is one of the most climate vulnerable countries in the world. Climate change accelerated the intensity and frequency of occurrences of drought, irregular rainfall, high temperature etc that directly and indirectly related to crop production. A field experiment was carried out at Pulses Research Sub-station, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the period from November, 2016 to March, 2017 to study the soil moisture, growth and yield of lentil with rice residual retention and tillage as a climate change adaptation technology. The experiment consisted of two factors as two residue retention viz., 15 cm residue retention**,** 45 cm residue retention and three conservation tillage viz., zero tillage**,** conventional tillage and strip tillage. The experiment was laid out into Randomized Complete Block design (RCBD) with three replications. Experimental results showed that residue retention had significant effect on moisture content of soil, growth and yield parameters except 1000 seeds weight. The seed yield (1.29 ton ha^{-1}), moisture content, growth parameters and all other yield parameters were higher at 45 cm residue retention. Different tillage also significantly influenced on moisture content of soil, growth and yield parameters for all the parameters of lentil. The results revealed that zero tillage produced maximum soil moisture content and highest seed yield (1.36 ton ha^{-1}) and strip tillage produced the lowest seed yield (1.04 ton ha^{-1}). In case of interaction effect of residue retention and different tillage, maximum soil moisture content found from 45 cm residue retention + zero tillage. The maximum number of pods per plant (55.33) and seeds per pod (2.04) was obtained from 45 cm residue retention + zero tillage. The highest seed yield (1.47 ton ha^{-1}) also observed in 45 cm residue retention + zero tillage. So, zero tillage with rice straw retention has a significant effect on soil moisture and crop yield.

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CHAPTER I

INTRODUCTION

Climate change adaptation is a response to global warming, that seeks to reduce the vulnerability of social and biological systems to relatively sudden change and thus offset the effects of global warming. Even if emissions are stabilized relatively soon, global warming and its effects should last many years, and adaptation would be necessary to the resulting changes in climate. Adaptation technology can be defined as the application of technology in order to reduce the vulnerability or enhance the resilience, of a natural or human system to the impact of climate change (Farber, 2007).

Crop residues are the remains of the crop after the valuable part has been harvested. For this intervention, residue retention is considered to be crop remains which are left in the field, rather than crop remains which are brought in from elsewhere and added to the soil. In Bangladesh cropping patterns are mainly intensive rice-based that promotes high levels of nutrient extraction from soils without allowing time for natural recovery (Alam *et al*., 2014). The use of excessive synthetic fertilizers exacerbates the debilitated soil fertility situation. Moreover, in Bangladesh, most of the farmers remove crop residues from the land for different purpose, specially fuel and fodder. Therefore, Soil Organic Matter (SOM) depletion is a main cause of low productivity, which is considered one of the most serious threats to the sustainability of Bangladesh agriculture (Rijpma and Jahiruddin, 2004). Crop residue in cropping systems like rice, wheat contains significant quantities of plant nutrients, their continuous application will have positive effect on Carbon stock build-up, soil health improvement and fertilizer management in the systems. Crop residue addition conserved Soil Organic Carbon (SOC) in the soil. The long-term input of different types of crop residues in soils managed under minimum tillage associated with crop rotation increase the Carbon pools. Retention or incorporation of crop residues can also play an important role in increasing SOC sequestration, increasing crop yield, improving soil organic matter and reducing the greenhouse gases. As an important agricultural practice, straw return to soil is often implemented with tillage in the production process. Although numerous studies have indicated that reduce tillage methods combined with straw return had a significant effect on labile SOC fractions, the results varied under different soil/climate conditions. (Naresh, 2017). Higher amount of residue retention increase soil moisture content, increase nutrient on soil and crop yield.

Tillage is the most important operation on crop production system. The process by which forces are imparted and changes in soil properties occur are known as tillage which is comprised of some technical operations such as ploughing and harrowing. Tillage practices control weeds, provide a suitable seed bed for crop plants, incorporate crop residues into the soil, make the soil loose, enhance chemical reaction and thereby improves the physicochemical condition of soil which in turn affect the growth and development of crop plants. Conservation tillage practices such as minimal soil disturbance with proper crop rotations could be a good option for Bangladesh to maintain soil health for better crop production and increasing crop yield. The traditional farming practice involves a series of tillage operations that break up the soil into smaller chunks to provide weed-free field during sowing. This system increases erosion, as well as the risk of soil structural degradation, and results in marked losses of soil moisture (Govaerts *et al*., 2009). Reduced tillage combined with crop residue retention on the soil surface can increase moisture infiltration greatly reduce erosion and increase water use efficiency. Conservation tillage reduce soil erosion and runoff as well as other benefits such as carbon sequestration. Conservation tillage methods include zero-tillage, strip-tillage, mulch tillage, conventional tillage etc. The cost of equipment for conservation will depend on whether the land is tilled with motorized tractor, animal draught or manpower. The most important cost for larger producers will be machinery and fuel. However, higher herbicide applications could be offset these savings, especially in the initial adaption stages. On smaller-sized farms, savings in labor costs could be substantial. Conservation tillage is needed to store the resources and this practices reduce risk from drought by reducing soil erosion, enhancing moisture retention and minimizing soil impaction. In combination, these factors improve resilience to climatic effects of drought and floods (Smith, 2005). Minimum disturbance of soil along with applying organic amendments and crop residues and including leguminous crops in the cropping systems increase soil fertility and health.

Lentil (*Lens culinaris* L.) occupies the top position in terms of popularity and has been placed second pulse in respect of area and production in Bangladesh (Bhuiyan, 2015). It is cultivated during rabi season under rainfed condition. The yield of lentil is very poor in Bangladesh. There is a great possibility to increase its production by exploiting better colonization of their root and rhizosphere through Rhizobium, which can also reduce the use of nitrogenous fertilizer as well as protect environment.

Over the years, it has been well established that pulses cultivation helps to increase soil fertility and maintain good soil health. However, the exact role of residue retention and different tillage in lentil is still poorly understood. The present study was therefore carried out to study the moisture condition of soil, growth and yield of lentil by retain residue and apply different tillage with the following objectives:

1. To find out the optimum level of rice residue for maximum soil moisture retention and yield;
2. To determine the suitable combination of residue retention and tillage for ensuring the maximum growth and higher yield of lentil.

CHAPTER II

REVIEW OF LITERATURE

2. 1 Effect of different tillage on soil

Alam *et al*. (2013) reported that soil physical properties viz. bulk density, particle density and porosity showed insignificant result due to tillage practices and cropping patterns but soil moisture retentive properties demonstrated significant outcomes. Deep tillage conserved moisture in the soil profile and improved other soil physical properties i.e. reduced the bulk density, increased porosity and available water content of soil. The highest yield of crop was recorded in the deep tillage and lowest in zero tillage with fallow based cropping pattern.

Altikat and Celik (2011) conducted a research and examined the effects of different soil tillage systems and intra-row compaction levels on the soil properties and red lentil emergence. They found horizontal axis rotary tiller had a tendency of giving higher water holding capacity and water availability. Vertical axis rotary tiller caused higher cone indexes and bulk density values. Conventional tillage tend to decrease the cone index and bulk density at the top layer of soil. The highest mean emergence time was found in conventional tillage and the lowest in vertical axis rotary tiller with roller and horizontal axis rotary tiller. Vertical axis rotary tiller with roller produced the maximum percentage of seedling emergence; the conventional tillage system illustrated the minimum.

Rahman *et al.* (2004) reported that the 4 passes at 15 cm deep ploughing by power tiller showed the highest yield of rice grain (4.95 t ha^{-1}) and straw (5.89 t ha^{-1}) which was associated with higher Leaf area index (LAI), Crop growth rate (CGR), Net assimilation rate (NAR), Total dry matter (TDM), leaf numbers/hill, plant height, number of total and effective tillers, panicle length, number of filled grains/ spikelets/ panicle and with lower number of non-bearing tillers/hill and sterile spikelets/panicle. The lowest values of all parameters were found in one pass with power tiller at both 7.5 and 15 cm depth. Though four passes with country plough at normal depth and three passes with power tiller at 15 cm depth showed statistically identical results of four passes with power tiller at 15 cm depth in respect of yield performance, this treatment (4 passes with power tiller at 15 cm depth) gave the highest yield practically.

Leghari *et al.* (2015) conducted a two years field experiment to investigate the effect of three tillage methods Conventional tillage, Reduced tillage and No tillage on the growth, development, yield and yield components of bread wheat (*Triticumaestivum* L. *cv.* TD-1). Results showed that conventional method caused substantial improvement in almost all the growth, yield and yield component traits of bread wheat in both the years, particularly it improved seedling emergence percentage, plant height, root system, number of main-stem leaves per plant, number of productive tillers per plant, number of spikelets per spike, spike length, number of grains per spike and grain and straw yields per hectare. However, the marginal return from reduced tillage treatment was greater for both the years as compared to other treatments.

Kosutic *et al.* (2005) found that the soil tillage systems greatly differ with respect to energy requirement. No-till system enabled saving of almost 85% energy, while conservation tillage system enabled saving of 37-39% energy per hectare and per yield unit in comparison to conventional tillage system. Labour requirement comparison showed that no-till soil system saved 76-80%, while conservation tillage system saved 43-46% of labour. Soil tillage systems differ with respect to achieved yields, but differences aren't statistically significant.

Busari *et al.* (2015) identified several benefits of conservation tillage over conventional tillage with respect to soil physical, chemical and biological properties as well as crop yields. Not less than 25% of the greenhouse gas effluxes to the atmosphere are attributed to agriculture. Processes of climate change mitigation and adaptation found zero tillage to be the most environmental friendly among different tillage techniques. Therefore, conservation tillage involving zero tillage and minimum tillage which has potential to break the surface compact zone in soil with reduced soil disturbance offers to lead a better soil environment and crop yield with minimal impact on the environment.

Dangolani and Narob (2013) observed significant difference in the performance of tillage systems in the three-year period on the one hand and benefits such as reducing fuel consumption, saving time, maintaining soil nutrients, and reducing costs on the other make no tillage systems a useful alternative for crop production. Increased water storage capacity of the soil is another advantage of using no-tillage farming. Considering the essential role of water for cultivation, especially cotton cultivation, increased water storage capacity due to crop residue cover can protect plants against evapotranspiration.

Altikat (2013) concluded that the highest crop yield was observed at the plot with tilled conventional tillage systems. The increase in the intra-row compaction level improved soil fertility and crop yield. The highest seed yield, numbers of pod per plant and first pod height were found in conventional tillage systems compared to reduced tillage systems. Intra-row compaction levels, significantly affected the seed yield, number of pods plant^{-1}and 1000 seeds weight. Increasing intra-row compaction level increased seed yield, number of pods per plant and 1000 seeds weight.

No till or zero tillage is an important component of conservation agriculture to produce crops at low cost with profound effect on natural resources such as water and soil (Gangwar *et al*., 2006).

Zero tillage is very effective in minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon in soil and reducing energy needs (Kumar *et al*., 2011).

Mazzocini *et al*. (2008) agreed that tillage plays a key role in cropping system sustainability due to its impact on soil properties and crop yields. They concluded from 16-yr (1990-2005) experiments in the rainfed area of central Italy that grain wheat yield under no-tillage was 8.9% lower than the conventional tillage and that nitrogen concentration in wheat was slightly affected by tillage.

Karlen *et al*. (1994) concluded that plots managed using no-till practices for 12 years had surface soil aggregates that were more stable in water and had higher total carbon, microbial activity, ergo sterol concentrations and earthworm populations than either the chisel or moldboard plow long-term no-till management had improved soil quality.

Singh *et al.* (1993) reviewed research on tillage systems and their role in soil and water conservation in south Asia. They reported that tillage has shown marked influences on soil hydraulic characteristics and to some extent on soil chemical and biological properties, particularly organic matter cycling. They emphasized the importance of conservation tillage in reducing runoff, soil loss and ensuring sustainable agricultural production in the region.

2.2 Effect of residue retention

Shafi *et al*. (2010) conducted a study and suggested that retention of residues on soil surface as mulch, incorporation of residues in soil and legume (lentil-maize) rotation improved the N economy of the cropping system and enhances crop productivity. Two years average data revealed that grain yield was increased by 3.31 and 6.72% due to mulch and residues incorporation. Similarly, stover yield was also enhanced by 5.39 and 10.27% due to the same treatment respectively. Mulch and residues incorporation also improved stover N uptake by 2.23 and 6.58%, respectively.

Kong (2014) reported that residue retention is not a single practice and must be performed with a complete set of techniques, including effective residue cutting, appropriate tillage patterns, correct sowing density and depth, appropriate compacting, and proper compacting tools. The correct selection of these elements would greatly contribute to sustainable agriculture in the target area. At present, reduced tillage combined with residue retention may be the most appropriate practice in most regions of China.

Management of crop residues on soil surface as mulch improves soil quality in terms of organic carbon and biotic activity. An increase in infiltration of water into the soil has also been reported by Bruce *et al*. (1992).

Shah *et al*. (2003) conducted an experiment and concluded, returning residues to the soil improves the N economy of the cropping system and enhances crop productivity through the additional N and other soil effects. The question of whether farmers who traditionally remove residues for fodder and fuel would change practices to return the residues to the soil will depend to a large extent on the relative profitability of both options.

Pandiaraj *et al.* (2015) reported that an improved crop residue management, combined with application of fertilizer N or incorporation of legumes greatly improves the N economy of cereal cropping systems and enhances crop productivity in soils with a low N content on the short term. Farmers who traditionally remove residues for fodder and fuel will require demonstration of the relative benefits of residues return to soil for sustainable crop productivity. Residues retention on average increased the grain yield by 1.31 times, straw yield by 1.38 times and N uptake by 1.32 times in grain and 1.67 times in straw of wheat. Green gram in rotation with wheat enhanced grain yield of wheat by 1.89 times, straw yield by 2.05 times and N uptake by 2.09 times in grain and 2.57 times in straw of wheat.

The recycling of crop residues has the advantage of converting the surplus farm waste into useful products for meeting nutrient requirements of crops. It also maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system. Research have shown that the return of crop residues on fragile soils improved the tilth and fertility of soil, enhanced crop productivity, reduced the wind and water erosion, and prevented nutrients losses by run-off and leaching (Lal,1980).

Sommer *et al*. (2014) showed that conservation agriculture had a positive impact on soil fertility. This was measurable by higher soil organic matter and microbial biomass contents, increased levels of extractable phosphate, sometimes (but not always) higher amounts of larger water-stable soil aggregates, increased soil infiltration capacity and soil water retention. The buildup of soil organic matter and associated carbon sequestration was in the range of 0.29 Mg C/ha/year, *i.e.* rather modest. High amounts of surface residues delayed the desiccation of the topsoil during the fallow period, but could not diminish the overall longer-term drying of the topsoil.

Gajri *et al.* (1994) concluded that proper combination of management practices like residues incorporation, mulching and manuring which increases depth and rooting density, can enhance the crop productivity of less water retentive coarse textured soil in arid and semiarid environment and alleviate water and nutrient stress.

Research under laboratory and field condition have shown that the use of surface organic mulch (straw) can result in storing more precipitation water in soil by reducing runoff, increasing infiltration and decreasing evaporation. In addition to reduce runoff, soil surface mulching with crop residues also reduces direct evaporation from wet soil surface and thus increases water availability (Jalota and Prihar, 1990).

If balanced fertilization is done in rainfed puddled rice and crop residues are retained on the soil surface in combination with suitable planting techniques of lentil, it may alleviate terminal drought condition in crops by conserving soil moisture and bring overall improvement in resource management (Ghosh *et al*., 2010).

Hammad and Battikhi (1995) conducted an experiment in the rainfed areas of Jordan involved the effect of three methods of land preparation (sweep, chisel and moldboard) and three different methods of wheat residue incorporation on soil moisture and crop yield. They concluded that the use of sweep resulted into the highest soil moisture depletion, soil rainfall storage, rainfall storage efficiency, water use efficiency and grain and straw yields. Late incorporation of residue (mid October) resulted into the highest soil rainfall storage efficiency and water use efficiency as compared to early incorporation of residue (August).

2.3 Effect of rice residue retention, tillage and their interaction

Kilic *et al*. (2015) reported that tillage and residue management practices and the timing of such practices influenced residue cover rate, seed emergence rate, weed density, hundred-seed weight and grain yield in lentil . Residue burning increased the rate of moisture loss and moisture loss was the greatest in the upper 10 cm of the soil profile in the short time. Also, residue burning resulted in lower percent residue cover than other residue management systems.

Salahin *et al*. (2017) reported that the soil organic carbon and moisture content were significantly increased in minimum tillage with three crop residue retention than all other treatment combinations, while the soil physical properties remained unchanged due to tillage-residue retention practices under the wheat-mungbean-rice cropping system. From 3-cropping cycle, it was also summarized that minimum tillage practice performed better in dry land crops (wheat and mungbean) and conventional tillage out-performed in case of low land crop.

Islam *et al*. (2016) suggest that minimum tillage and higher residue retention enhanced cool season crop yield in the intensive rice-based cropping systems of the EIGP but it takes 2-3 years to derive the main benefits for crop productivity.

Battikhi *et al.* (2011) conducted an experiment for 10 years (1990 to 2000) in 3 different rainfall zones of Jordan to study the effect of tillage and wheat residue management methods on soil moisture storage from rainfall and crop yield under different crop rotations. The results showed significant effects for certain tillage treatments on total actual evapotranspiration, but no effects on water use efficiency or yield. Using the sweep plow is the most suitable for the land preparation for wheat or lentil planting in case of wheat/lentil rotation. Wheat yield in the three year rotation (wheat/lentil/melon) in the high and medium rainfall zones was higher than wheat yield after lentil in the two year rotation (wheat/lentil). Rainfall use efficiency (RUE) decreased in the wet season compared to the dry season. No significant differences were found among the three methods of wheat residue management, therefore, in wind erosion affected regions, incorporation of residue late in the season is recommended.

Bandyopadhyay *et al*. (2016) found that zero tillage with straw mulch in lentil varieties conserved 12-20% more water than residue removal and 7-10% more than standing residue respectively. Depletion was more in residue removal, followed by standing residue and mulch that could influence soil drying through increasing soil stress and resistance.

The roots and above ground residues, remaining after the seed and other components of the crop have been harvested, represent a potentially valuable source of N for replenishing soil N pools. Mineral N in root-zone soil following grain legumes is often 30–60 kg N/ha higher than after cereal crops in the same environment. (Evans *et al*., 1989).

Naresh (2017) reported that conservation agriculture based management systems such as reduced or no tillage, crop residue addition, farm yard manure incorporation, and intregated nutrient management can increase soil organic carbon accumulation and improve sustainability of agricultural systems. No tillage can increase soil aggregations, improve soil properties, and favorably influence soil organic carbon accretion. Effects of crop residue addition are often observed when they are integrated with reduced tillage systems or with improved nutrient management.

Limon-Ortega *et al.* (2002) reported that reduced tillage combined with crop residue retention on the soil surface can increase moisture infiltration, greatly reduce erosion, and increase water use efficiency, compared to conventional tillage. Results of field research are increased moisture levels, decreased soil temperatures, and more stable soil aggregates in case of less tillage.

Govaerts *et al*. (2008) indicated that wheat production under zero conventional tillage with residue removal was an unsustainable practice in terms of plant population and soil quality improvement, while tillage with residue retention was a viable sustainable practice for small holder farmers in the volcanic highlands of Mexico and comparable regions of the world.

Govaerts *et al*. (2007) concluded from a long-term field experiment conducted at the semi-arid high land station of CIMMYT in Mexico that in a cropping system that includes zero tillage, crop rotation and crop residue retention can increase the overall biomass and microflora activity and density compared to common farming practices.

Schroth *et al.* (1995) reported that plant biomass retention on soil increase crop yield and zero tillage improve soil health. In the ploughed treatments, soil fertility declined rapidly during the experiment, probably because of increased soil erosion, surface runoff and mineralization of soil organic matter, leading to losses of P and (non-significant) C, N and basic cations. Soil acidification was accelerated accordingly. This indicates a trade-off between short-term yield improvement and medium-term degradation of soil fertility by level ploughing compared with the traditional soil tillage method. Ridging seems better suited than level ploughing for these sites. For reasons of soil protection and labour economy, mulching is preferable to green manuring.

Al-Turshan and Battikhi (1993) calculated in an experiment conducted to study soil quality as affected by tillage and residue under rice-wheat cropping system in a vertisol of India that using zero tillage for wheat had a positive effect on soil quality regardless of the treatments used for rice.

Barley grown under moldboard plowing in a semiarid environment had higher biomass compared with that plowed by chisel. Barley grain yield was greater under moldboard plowing in fallow-fallow-barley rotation (Ghosheh and Al-Hajaj, 2004).

CHAPTER III

MATERIALS AND METHODS

A sequential description of the methodologies that was followed in conducting this research work has been presented in this chapter under the following headings-

3.1 Site Description

3.1.1 Geographical Location

The experiment was conducted at the Pulse Research Sub-station , Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the period from November, 2016 to March, 2017. The experimental area was situated at 23°98′N latitude and 90°41′E longitude at an altitude of 8.6 meter above the sea level.

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of “The Modhupur Tract”, AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has sub-tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity and rainfall prevailed at the experimental site during the study period was presented in Appendix II.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Chhiata Series. The experiment site has clay loam soil textural class at 0 - 15 and 16 - 30 cm soil depths having bulk density and particle density of 1.54 and 2.52 g cm^{-3}, while the porosity was 39%. The soil was slightly acidic (pH-6.6) and low in organic carbon (OC; 0.61%) and total N (TN; 0.046%) in the surface soil, whereas OC (0.38%) and TN (0.32%) were much lower in the lower layer of soil (Salahin *et al*., 2017). The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

(A) Residue retention:

In the field when the experiment started the previous crop was Aman rice. The experiment plot was prepared with keeping two type of rice straw in the field. After a certain period straw were decomposed or some specific field it mixed with soil by different tillage. The two types residue retention is given below:

i. R_1 = 15 cm residue retention from the ground level to upper part.
ii. R_2 = 45 cm residue retention from the ground level to upper part.

(B) Different type tillage:

Three types of tillage practices were practiced for this experiment. Based on the practices adopted by farmers due to machinery availabilities, power tiller is used which can till up to 10 - 12 cm depth. The following three tillage practices were selected:

i. T_0 = Zero tillage, where no tillage is done.
ii. T_1 = Conventional tillage, where depth was up to 12 - 15 cm.

iii. T_2 = Strip tillage, where strip/row is created 5-6 cm wide in every 30 cm distance and depth was up to 10-12 cm. The 30 cm residue retention space was not ploughed between every two row.

3.2.2 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications having two factors. There were 6 treatment combinations. The total numbers of unit plots were 18. The size of unit plot was 3m × 2m ($6m^2$). The distances between each plots were 1m.

3.3 Crop/Planting Material

BARI Masur - 7 was used as plant material.

3.3.1 Description of Variety

BARI Masur - 7 is cultivated all kind of soil but sandy loam soil is better. It is also suitable for cultivating as relay crop. Crop duration is 110 to 115 days. Plant height 32-38 cm, pod number 55-60, 1000 seeds weight 21-22 gm and yield is 1.8-2.3 ton/ha.

3.4 Crop Management

3.4.1 Seed Collection

Seeds of BARI Masur - 7 were collected from Pulses Research Sub-station, BARI, Joydebpur, Gazipur, Bangladesh.

3.4.2 Preparation of Experimental Land

Rice was harvested and then the experimental field was ploughed on November 22, 2016 by three successive ploughings in conventional and strip tillage plot. All weeds were removed from the field by hand Nirani. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were used as a source of nitrogen, phosphorous and potassium, respectively in the experimental plot. Urea, TSP and MOP were applied in broadcast at the rate of 30, 90 and 40 kg per hectare, respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation for lentil cultivation. All the fertilizers were applied during final land preparation.

3.4.3 Seed sowing

The lentil seeds were sown at November 23 in 2016. Seeds were treated with Provex 200 wp at the rate of 3g/kg of seeds before sowing the seeds to control the seed borne diseases. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm. Line to line distance was 30cm. Seeds were sowing by broadcast method in every row.

3.5 Intercultural operations

3.5.1 Thinning

Seeds were germinated 7-8 days after sowing (DAS). Thinning was done at 20 DAS to maintained 2-3 cm between plants to obtained proper plant population in each plot.

3.5.2 Irrigation and weeding

Irrigation was done at 35 DAS. The crop field was weeded twice; first weeding was done at 20 DAS and second at 40 DAS.

3.5.3 Protection against pests

Rovral was applied at the rate of 2g/L of water for two times – 60 DAS and 80 DAS for controlling Stemphylium blight.

3.6 Crop sampling

Ten plants from each plot were randomly marked inside the central row of each plot with the help of sample card for data collection.

3.7 Harvesting and processing

The crop was harvested when more than 80% pods were matured at 12 March, 2017. For collection of data the harvested crops were separated treatment wise. After separation pods were dried in sunlight, and then shelled and the seeds were cleaned properly. Dry weight was recorded after oven drying. Seed weight was recorded after 3 days sun drying.

3.8 Collection of data

Data was collected from each sample plant and mean value was calculated.

The following data were recorded.

i. Moisture content of soil (%)
ii. Plant height (cm)
iii. Number of branches plant^{-1}
iv. Dry weight plant^{-1}(gm)
v. Pod plant^{-1}
vi. Seed pod^{-1}
vii. 1000 seeds weight (gm)
viii. Seed yield (ton/ha)

3.8.1 Moisture content of soil (%)

Soil samples at 0-15 cm depths were collected from each plot during seed sowing, 40 DAS, 60 DAS and harvest period. Soil moisture content was measured following gravimetric method.

$$\% \text{ Soil water} = \frac{\text{Weight of wet soil(gm)-weigh of dry soil (gm)}}{\text{Weight of dry soil(gm)}} \times 100$$

3.8.2 Plant height (cm)

Plant height of 10 randomly selected plants was measured with a meter scale from the ground level to the tip of the plants and the mean height was expressed in cm. Data were recorded from the inner rows of each plot starting from 40 DAS at 20 days interval up to harvest.

3.8.3 Number of branches plant^{-1}

Branches were counted from selected plants starting from 40 DAS at 20days interval up to harvest. The total branches of 10 plants were averaged to have number of branches plant^{-1}.

3.8.4 Dry weight plant^{-1}

Ten sample plants from each plot were collected and gently washed with tap water, thereafter soaked with paper towel. The sample was oven dried at 70^0C for 72 hours. Then oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature, thereafter dry weight of plants was taken and expressed in gram. Above ground dry matter plant-1 was recorded at 40, 60, 80 DAS and at harvest.

3.8.5 Pods plant^{-1}

Total pods of selected plants from each plot were counted and the mean numbers were expressed as pods plant^{-1} basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

3.8.6 Seeds pod^{-1}

Seeds pod^{-1} was recorded randomly from selected plants at the time of harvest. Data were recorded as the average of 10 pods selected at random from the inner rows of each plot.

3.8.7 1000 seed weight

One thousand cleaned, dried seeds were counted from each harvested sample and weighed by using a digital electric balance and weight was expressed in gram (gm).

3.8.8 Seed yield (ton/ha)

The seeds collected from 3 m^2 (3 m×1 m) area of each plot were sun dried properly. The weight of seeds was taken and converted the yield in ton per ha.

3.9 Statistical analysis

The data obtained for different parameters were statistically analyzed using MSTAT-C software. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

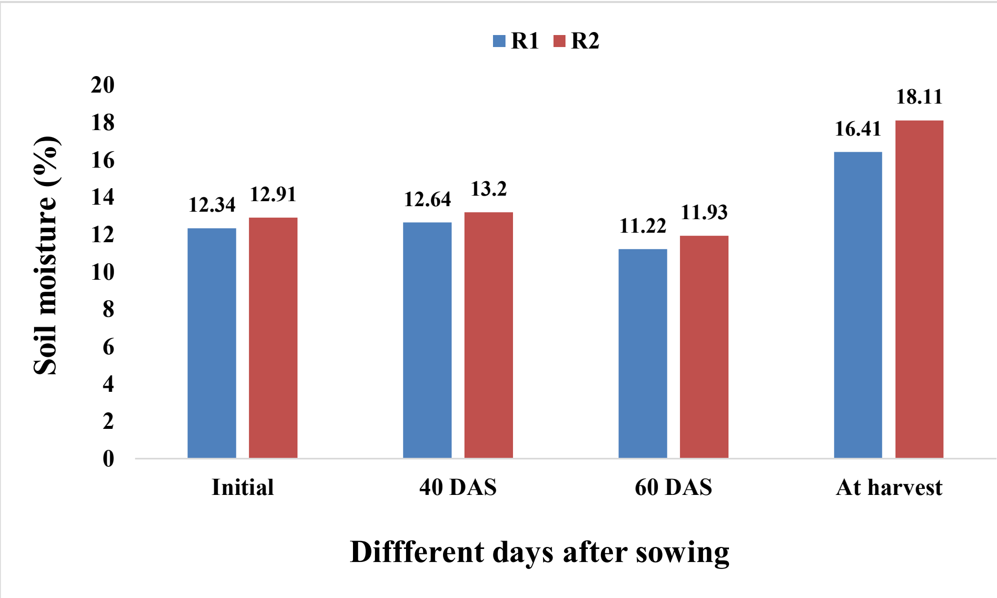
RESULTS AND DISCUSSION

Results obtained from the present study regarding the assessment of lentil under residual retention and tillage as a climate change adaptation have been presented, discussed and compared in this chapter. The analytical results have been presented in Table 1 to 5, Figure 1 to 16 and Appendix III to VIII.

4. 1 Soil moisture content at different time

4.1.1. Effect of rice residue retention

The soil moisture content was significantly varied by different rice residue retention at initial time, 40, 60 DAS and harvest period (Figure 1 and Appendix III). The higher soil moisture content was observed in 45 cm residue retention (12.91, 13.20, 11.93 and 18.11% respectively) at initial time, 40, 60 DAS and harvest period due to heavy rainfall and lower in 15 cm residue retention (12.34, 12.64, 11.22 and 16.41% respectively).



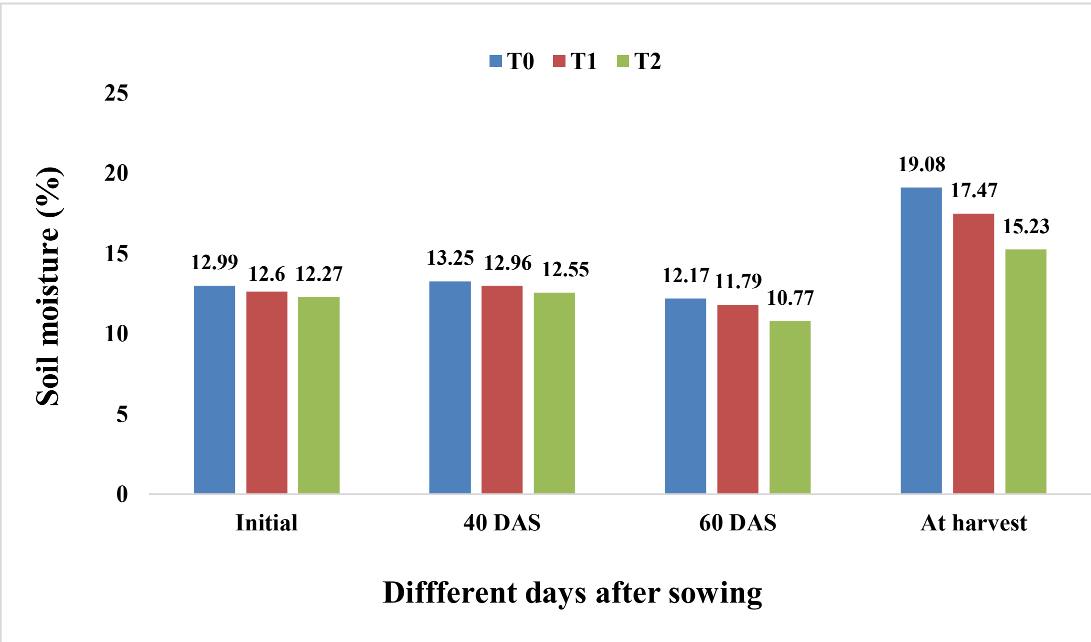
R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 1. Influence of rice residue retention on soil moisture content at different growth stages of BARI Masur– 7

Salahin (2017) reported the highest soil moisture content was found in that plot where maximum crop residues were retained followed by minimum residues retained plots in his experiment. This was might be much more organic matter accumulated under 45 cm residue retention which started conserving more soil moisture compare to 15 cm residue retention.

4.1.2. Effect of different tillage

The soil moisture content percentage influenced by different tillage at initial time, 40, 60 DAS and harvest period (Figure 2 and Appendix III) . The highest moisture content percentage was recorded from zero tillage (12.99, 13.25, 12.17 and 19.08%, respectively) at all growth stages that statistically similar with conventional tillage at 40 DAS. The lower moisture content percentage was recorded in strip tillage at all stage (12.27, 12.55, 10.77 and 15.23%, respectively) that statistically similar with conventional tillage at initial stage. This results is agreement with the findings of (Dangolani *et al.,* 2013), who reported that zero tillage increases moisture content percentage of soil because zero tillage system increases soil's water storage capacity.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 2. Influence of different tillage on soil moisture content at different growth stages of BARI Masur - 7

4.1.3. Interaction effect of rice residue retention and different tillage

Interaction effect of rice residue retention and different tillage significantly influenced moisture content percentage of soil at initial time, 40, 60 DAS and harvest period (Table 1 and Appendix III).The highest moisture content percentage was obtained from 45 cm residue retention + zero tillage in all four different growth stages (13.42, 13.65, 12.70 and 20.27%, respectively) that statistically similar with 45 cm residue retention + conventional tillage at 40 DAS and harvest period. The lowest moisture content percentage was found from 15 cm residue retention + strip tillage (12.08, 12.36, 10.33 and 14.53%, respectively) in all growth stage that statistically similar with 15 cm residue retention + zero tillage and 15 cm residue retention + conventional tillage at initial stage and 40 DAS.

Table 1. Interaction effect of rice residue retention and different tillage on Soil moisture content at different growth stages of BARI Masur-7

Treatments	Soil moisture content (%) at different days after sowing			
	Initial	40 DAS	60 DAS	At harvest
R_1T_0	12.57 bc	12.85 bc	11.63 bc	17.9 bc
R_1T_1	12.36 bc	12.71 bc	11.68 b	16.8 bc
R_1T_2	12.08 c	12.36 c	10.33 d	14.53 d
R_2T_0	13.42 a	13.65 a	12.7 a	20.27 a
R_2T_1	12.83 b	13.21 ab	11.9 b	18.13 ab
R_2T_2	12.47 b	12.75 bc	11.2 c	15.93 cd
$LSD_{(0.05)}$	0.53	0.58	0.45	2.18
CV (%)	5.31	14.45	12.41	6.95

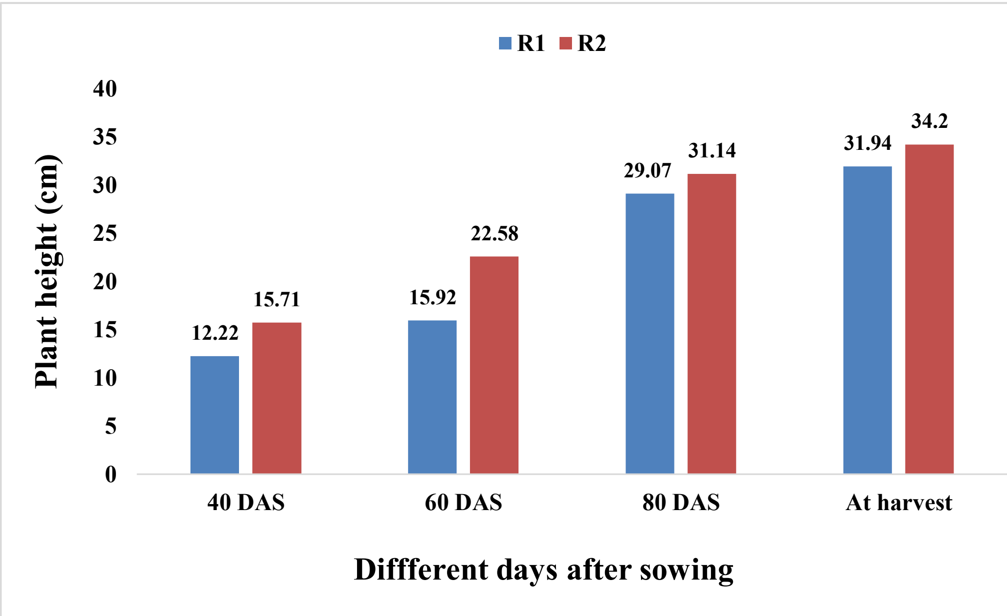
R_1 = 15 cm residue retention, R_2 = 45 cm residue retention, T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

4.2 Crop growth parameters

4.2.1 Plant height

4.2.1.1. Effect of rice residue retention

The plant height of lentil was significantly influenced by different rice residue retention at 40, 60, 80 days after sowing (DAS) and at harvest (Figure 3 and Appendix IV). The result revealed that at 40, 60, 80 DAS and at harvest, 45 cm residue retention produced the tallest plant (15.71, 22.58, 31.14 and 34.20 cm, respectively). The minimum plant height was observed in 15 cm residue retention at all growth stage (12.22, 15.92, 29.07 and 31.94 cm, respectively). The increase of plant height was very slow in the initial growth stage and then the crop remained in vegetative stage. The rapid increase of plant height was observed from 60 to 80 DAS. It was observed that in vegetative stage, the growth of plant was very slow. Similar result was found by Altikat (2013). He mentioned maximum plant height of lentil was increased with the increase of residue retention of previous crop. Feizabady (2013) also reported that 50% residue retention of rice increased the plant height of crops.

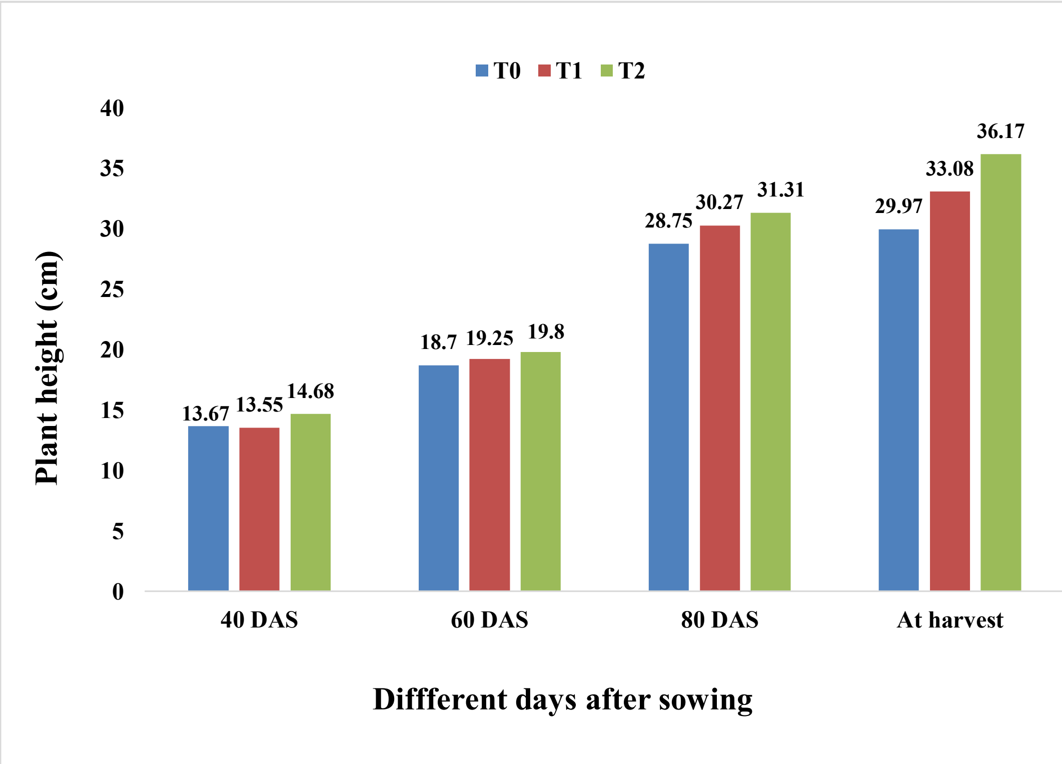


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 3. Influence of rice residue retention on plant height at different growth stages of BARI Masur - 7

4.2.1.2. Effect of different tillage

Significant variation of plant height was found due to different tillage in all the studied durations except at 60 DAS (Figure 4 and Appendix IV). It was observed that strip tillage increase the height of lentil crop. At 40, 80 DAS and harvest period strip tillage produced the tallest plant (14.68, 31.31 and 36.17 cm, respectively) which was statistically similar with conventional tillage at 80 DAS. Zero tillage produced the shortest plant of lentil at 80 DAS and harvest period (28.75 and 29.97 cm respectively). Conventional tillage produced the shortest plant at 40 DAS (13.55 cm) which was statistically similar with zero tillage.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 4. Influence of different tillage on plant height at different growth stages of BARI Masur - 7

The present finding also agreed to the result of Rahman *et al.* (2004). They reported, plant height was significantly affected by different tillage practices. Plant height was increased with the advancement of growth stages. Number of passes and depth resulted significant effect, higher number of passes caused higher plant height. The four passes with power tiller at 15 cm depth gave the highest plant height at all growth stages. A similar results on tillage treatment was obtained by Olofintoye (1989).

4.2.1.3. Interaction effect of rice residue retention and different tillage

Significant interaction effect between the rice residue retention and different tillage was observed at 40, 60, 80 DAS and at harvest (Appendix IV and Table 2). At 40 DAS 45 cm residue retention + conventional tillage produced tallest (17.10 cm) plant and 15 cm residue retention + conventional tillage produced the shortest (10 cm, 15 cm) plant at 40 and 60 DAS. At 60, 80 DAS and harvest period 45 cm residue retention + strip tillage produced the longest plant (22. 07, 32.83 and 38.00 cm) and 15 cm residue retention + zero tillage produced the shortest plant (27.83 and 29.00 cm) at 80 DAS and harvest period which was statistically similar with 15 cm residue retention + zero tillage 80 DAS. Jakhar *et al*. (2018) reported similar result, strip tillage with 4 ton/ha residue retention (more residue retention) gave the maximum height of crop.

Table 2. Interaction effect of rice residue retention and different tillage on plant height at different growth stages of BARI Masur - 7

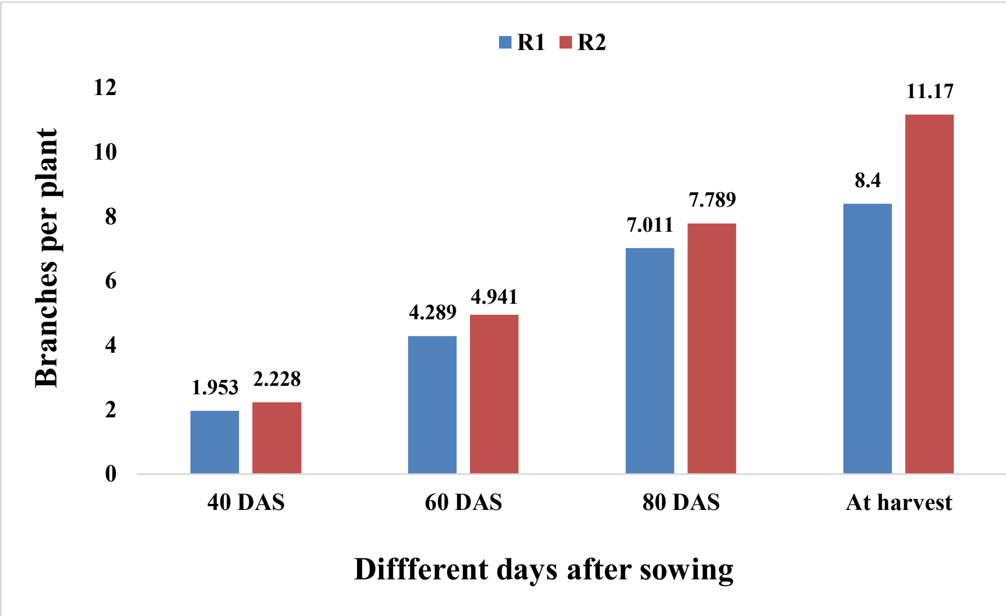
Treatments	Plant height at different days after sowing			
	40 DAS	60 DAS	80 DAS	At harvest
R_1T_0	12.50 c	15.23 c	27.83 c	29.00 e
R_1T_1	10.00 d	15.00 c	29.60 bc	32.50 c
R_1T_2	14.17 b	17.53 b	29.78 b	34.33 b
R_2T_0	14.83 b	22.03 a	29.67 b	30.93 d
R_2T_1	17.10 a	22.05 a	30.93 b	33.67 bc
R_2T_2	15.20 b	22.07 a	32.83 a	38.00 a
LSD $_{(0.05)}$	1.37	1.78	1.8	1.5
CV (%)	5.39	5.08	8.1	9.26

R_1 = 15 cm residue retention, R_2 = 45 cm residue retention, T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

4.2.2 Number of branches plant^{-1} at different growth stages

4.2.2.1. Effect of rice residue retention

The production of total number of branches plant^{-1} of lentil was significantly influenced by different residue retention at 60, 80 DAS and at harvest but not at 40 DAS (Figure 5 and Appendix V). The higher number of branches per plant was observed in 45 cm residue retention at 60, 80 DAS and at harvest (4.94, 7.79, and 11.17, respectively) and the lower in 15 cm residue retention (4.28, 7.01 and 8.40, respectively). Bhagat (1990) reported that higher residue retention was responsible for vigorous growth of crop in his study.

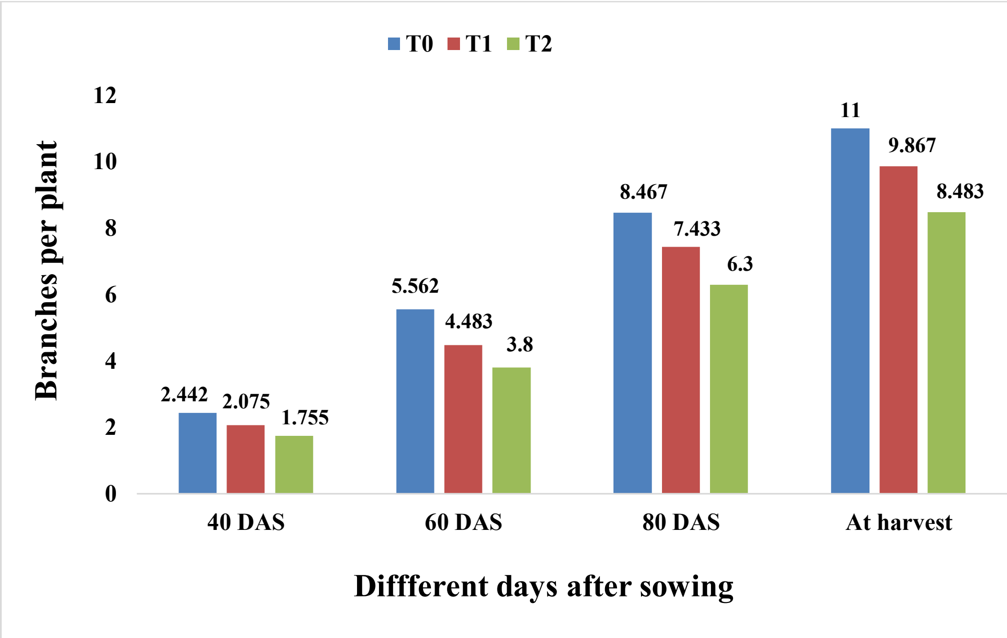


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 5. Influence of rice residue retention on number of branches per plant at different growth stages of BARI Masur - 7

4.2.2.2. Effect of different tillage

The production of total number of branches plant^{-1} was significantly influenced by different tillage at 40, 60, 80 DAS and at harvest (Figure 6 and Appendix V). The highest number of branches plant^{-1} was recorded from zero tillage (2.44, 5.56, 8.46 and 11.00, respectively) at all growth stage that statistically similar with conventional tillage at 40 DAS. The lowest branches was recorded in strip tillage at all stage (1.75, 3.80, 6.30 and 4.48, respectively). This results is agreement with the findings of (Kilic *et al*., 2015), who reported that zero tillage increased the number of branches per plant.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 6. Influence of different tillage on number of branches per plant at different growth stages of BARI Masur - 7

4.2.2.3. Interaction effect of rice residue retention and different tillage

Interaction effect of rice residue retention and different tillage produced significant variation on branches number at 40, 60, 80 DAS and at harvest (Appendix V and Table 3). The highest number of branches plant^{-1} was obtained from 45 cm residue retention + zero tillage all four different growth stage (2.63, 5.92, 8.90 and 12.50, respectively) that statistically similar with 45 cm residue retention + conventional tillage and 15 cm residue retention + zero tillage. The lowest number of branches plant^{-1} was found from 15 cm residue retention + strip tillage (1.66, 3.50, 6.00 and 7.20 respectively).

Table 3. Interaction effect of rice residue retention and different tillage on number of branches at different growth stages of BARI Masur- 7

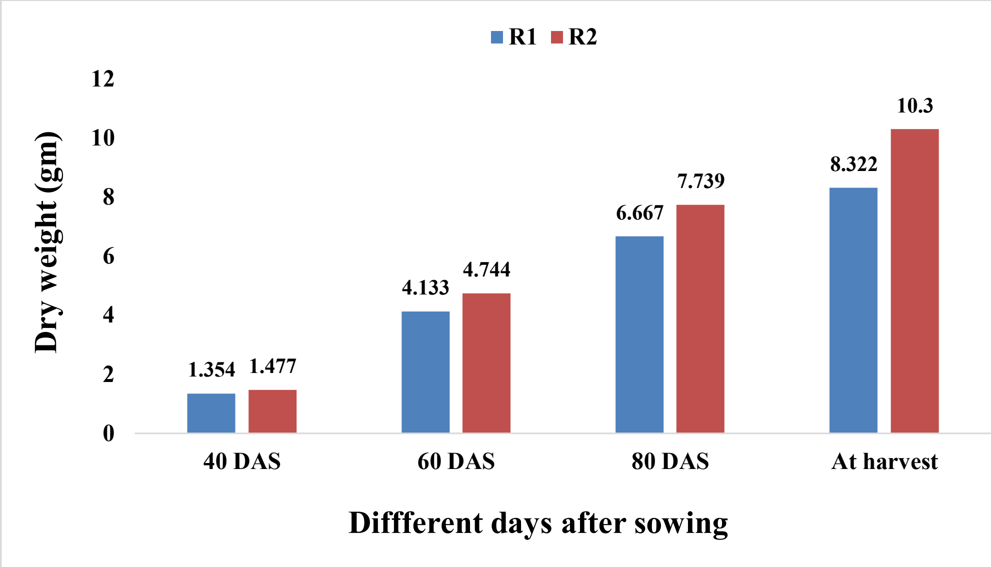
Treatments	Number of branches at different days after sowing			
	40 DAS	60 DAS	80 DAS	At harvest
R_1T_0	2.25 ab	5.20 b	8.03 b	9.50 c
R_1T_1	1.95 b	4.17 cd	7.00 c	8.50 d
R_1T_2	1.66 b	3.50 e	6.00 d	7.20 e
R_2T_0	2.63 a	5.92 a	8.90 a	12.50 a
R_2T_1	2.20 ab	4.80 bc	7.87 b	11.23 b
R_2T_2	1.85 b	4.10 de	6.60 c	9.77 c
LSD $_{(0.05)}$	0.65	0.66	0.44	0.72
CV (%)	10.15	3.72	9.1	10.03

R_1 = 15 cm residue retention, R_2 = 45 cm residue retention, T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

4.2.3 Dry weight plant^{-1}

4.2.3.1. Effect of rice residue retention

Different residue retention significantly influenced the dry weight plant^{-1} of lentil at 60, 80 DAS and at harvest but not any significant different at 40 DAS (Figure 7 and Appendix VI). It was observed that, higher dry weight plant^{-1} was observed on 45 cm residue retention at 60, 80 DAS and harvest period (4.74, 7.74 and 10.30 gm, respectively) and lower (4.13, 6.67 and 8.32 gm) at 15 cm residue retention. Meena *et al*. (2015), reported similar result. They showed adding residue retention increase the dry weight of crop. Shah *et al.* (2003) reported, higher residue retention increased shoot biomass of both the summer and winter crops.

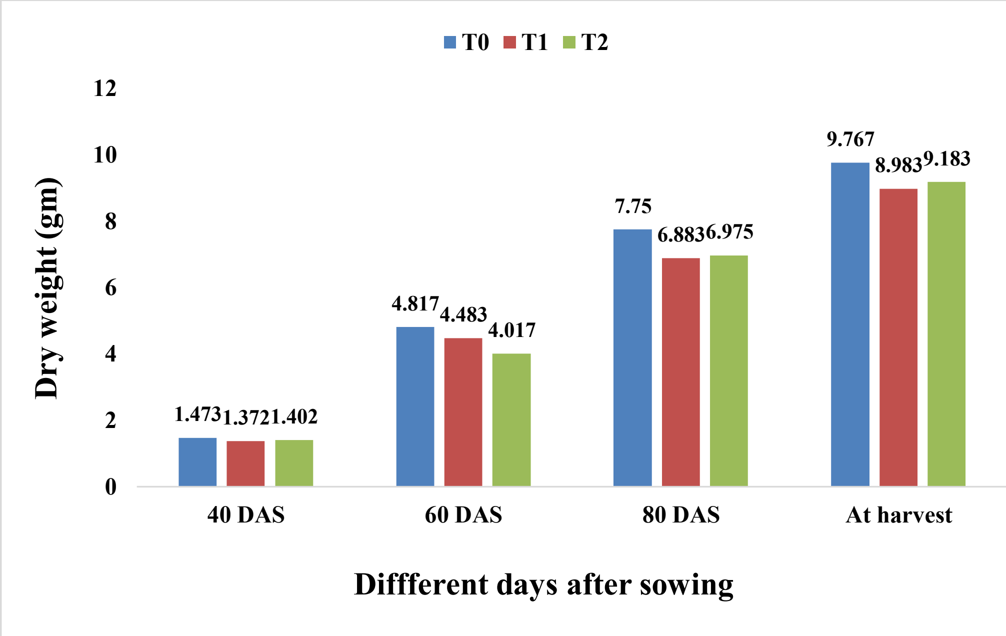


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 7. Influence of rice residue retention on dry weight per plant at different growth stages of BARI Masur - 7

4.2.3.2. Effect of different tillage

The total dry weight plant^{-1} of lentil was significantly influenced by different tillage at 60, 80 DAS and at harvest but not any significant difference at 40 DAS (Figure 8 and Appendix VI). The highest dry weight was recorded in zero tillage (4.81, 7.75 and 9.77 gm, respectively) at 60, 80 DAS and harvest period. The lowest dry weight (4.01, 6.96 and 9.18 gm, respectively) at 60, 80 DAS and harvest period was found in strip tillage that was statistically similar with conventional tillage at 80 DAS and harvest period. This findings is agreed to result of Meena *et al.* (2015). They found that zero tillage showed significantly weight of plant.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 8. Influence of different tillage on dry weight per plant at different growth stages of BARI Masur – 7

4.2.3.3. Interaction effect of rice residue retention and different tillage

Interaction effect of rice residue retention and different tillage influenced the dry weight plant^{-1} of lentil at all growth stage except 40 DAS (Table 4 and Appendix VI). The higher dry weight was observed on 45 cm residue retention + zero tillage at 60 DAS and harvest period (4.83 and 10.70 gm) that statistically similar with 15 cm residue retention + zero tillage, 45 cm residue retention + convention tillage and 45 cm residue retention + strip tillage at 60 DAS. 45 cm residue retention + strip tillage produced highest dry weight at 80 DAS that statistically similar with 45 cm residue retention + zero tillage and 15 cm residue retention + zero tillage. The lower dry weight was observed on 15 cm residue retention + strip tillage at 60 and 80 DAS that statistically similar with 15 cm residue retention + conventional tillage at 80 DAS. At harvest period 15 cm residue retention + conventional tillage produced the lower dry weight that similar with 15 cm residue retention + strip tillage. At Interaction between zero tillage with higher residual retention increase the dry weight of crop. (Meena *et al.,* 2015).

Table 4. Interaction effect of rice residue retention and different tillage on dry weight per plant at different growth stages of BARI Masur- 7

Treatments	Dry weight per plant at different days after sowing			
	40 DAS	60 DAS	80 DAS	At harvest
R_1T_0	1.45	4.80 a	7.50 ab	8.83 c
R_1T_1	1.33	4.23 b	6.60 cd	8.00 d
R_1T_2	1.29	3.37 c	5.90 d	8.13 d
R_2T_0	1.50	4.83 a	8.00 ab	10.70 a
R_2T_1	1.41	4.73 ab	7.17 bc	9.97 b
R_2T_2	1.52	4.67 ab	8.05 a	10.23 b
$LSD_{(0.05)}$	NS	0.52	0.84	0.39
CV (%)	6.33	6.39	6.42	10.27

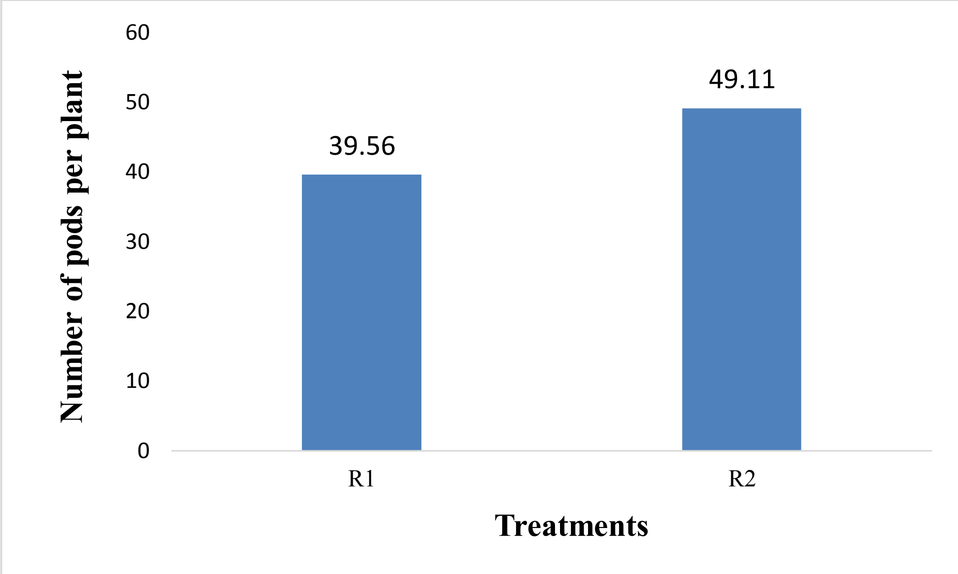
R_1 = 15 cm residue retention, R_2 = 45 cm residue retention, T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

4.3 Crop yield parameters

4.3.1 Number of pods plant^{-1}

4.3.1.1. Effect of rice residue retention

The pod plant^{-1} significantly varied among the rice residue retention (Figure 9 and Appendix VII), where 45 cm residue retention gave the higher number (49.11) of pod per plant and 15 cm residue retention gave the lower (39.56) pod per plant. The presence of high amount of crop residues around seeds can impede adequate seed-to soil contact needed for good crop emergence by increasing the macroporosity which is known to decrease the degree of contact and increase the number of pod per plant as well as yield of plant (Himel *et al*., 2018).

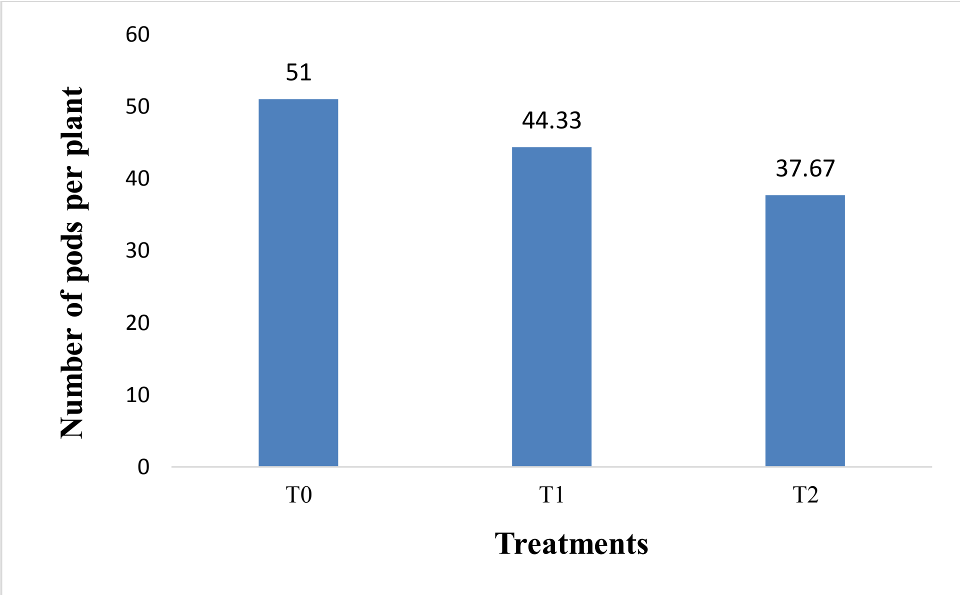


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 9. Influence of rice residue retention on number of pods per plant of BARI Masur - 7

4.3.1.2. Effect of different tillage

Different tillage affected the number of pods per plant of lentil (Figure 10 and Appendix VII). Zero tillage produced the highest number of pod per plant (51.00) and strip tillage produced the lowest number of pod per plant (37.67). This result is agreed to findings of Olaoye (2002). They reported tillage treatments has a significant effect on number of pods per plant and zero tillage increase pod per plant. However this result is contradictory with the findings of Altikat (2013). He reported, the numbers of pods per plant is higher in conventional tillage system compared to reduced tillage systems.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 10. Influence of different tillage on number of pods per plant of BARI Masur - 7

4.3.1.3. Interaction effect of rice residue retention and different tillage

Interaction effect of rice residue retention and different tillage significantly influenced the pods per plant (Table 5 and Appendix VII).

Table 5. Interaction effect of rice residue retention and different tillage on pod per plant, seed per pod, 1000 seed weight and seed yield of BARI Masur-7

Treatments	Pods $plant^{-1}$	Seeds pod^{-1}	1000 seeds weight	Seed Yield (ton/ha)
R_1T_0	46.67 bc	1.66 bc	21.20	1.25 b
R_1T_1	39.67 cd	1.43 c	19.70	1.15 b
R_1T_2	32.33 d	1.45 c	21.97	0.93 c
R_2T_0	55.33 a	2.04 a	22.50	1.47 a
R_2T_1	49.00 ab	1.78 ab	22.17	1.25 b
R_2T_2	43.00 bc	1.52 bc	21.93	1.16 b
LSD $_{(0.05)}$	8.06	0.29	NS	0.14
CV (%)	9.99	7.35	10.27	6.69

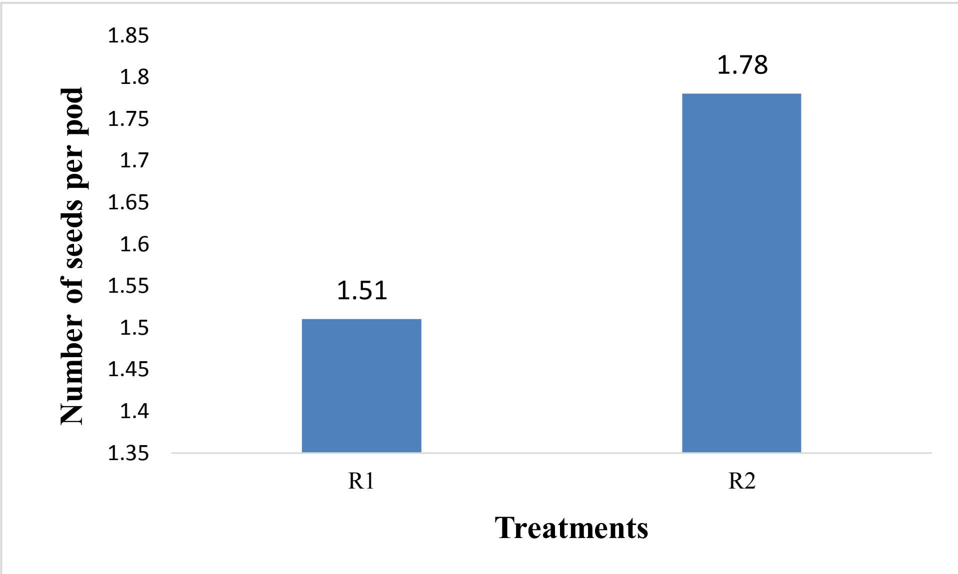
R_1 = 15 cm residue retention, R_2 = 45 cm residue retention, T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

45 cm residue retention + zero tillage produced the highest number of pods per plant (55.33) which was statistically similar with 45 cm residue retention + conventional tillage. The lowest number of pod (32.33) per plant was observed on 15 cm residue retention + strip tillage that similar with 15 cm residue retention + conventional tillage.

4.3.2 Number of seed pod^{-1}

4.3.2.1 Effect of rice residue retention

Rice residue retention showed significant effect on number of seed pod^{-1} (Figure 11 and Appendix VII). The highest number of seeds pod^{-1} (1.78) was found from 45 cm residual retention and the lowest number (1.52) was found from 15 cm residual retention. Feizabad (2013) observed that 50 % residue retention increase the number of seeds on crop.Jahkar *et al.* (2018) reported 4 ton per hectare residue retention give significantly higher values of seed per pod.

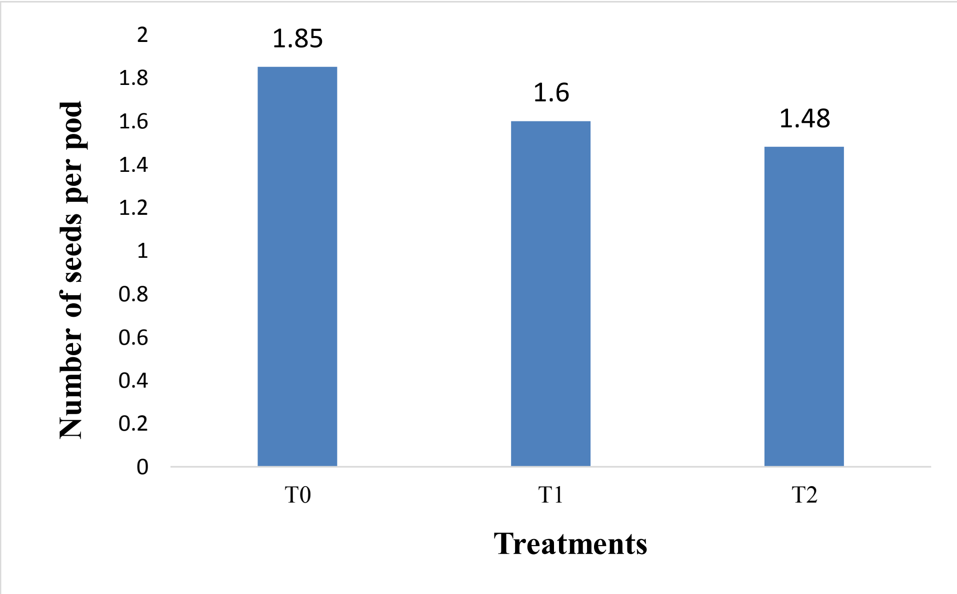


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 11. Influence of rice residue retention on number of seeds per pod of BARI Masur - 7

4.3.2.2. Effect of different tillage

Number of seeds per pod also significantly influenced by different tillage (Figure 12 and Appendix VII). The highest number of seeds per pod (1.85) was found from zero tillage and the lowest number of seeds per pod (1.48) was found in strip tillage that statistically similar with conventional tillage.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 12. Influence of different tillage on number of seeds per pod of BARI Masur - 7

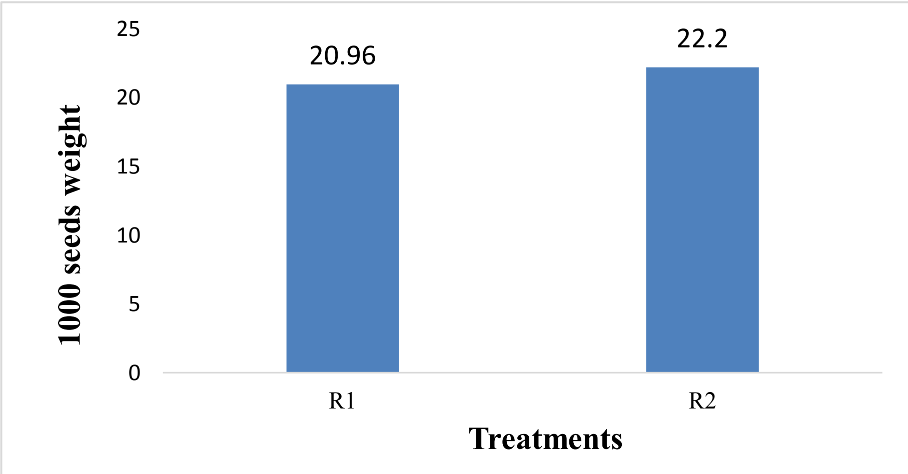
4.3.2.3. Interaction effect of rice residue retention and different tillage

There was a significant effect with interaction between rice residue retention and different tillage in respect of number of seed per pod of lentil (Table 5 and Appendix VII). The highest number of seed per pod (2.04) was recorded in 45 cm residue retention + zero tillage that similar with 45 cm residue retention + conventional tillage. The lowest number of seed per pod (1.43) was recorded in 15 cm residue retention + conventional tillage that similar with 15 cm residue retention + strip tillage. Jakhar *et al.*(2018) reported combination effect of zero tillage with higher residue retention increase the number of seed per pod. Similar findings was also published by Meena *et al.* (2015).

4.3.3 1000 seeds weight

4.3.3.1 Effect of rice residue retention

Rice residue retention not showed any significant difference on 1000 seed weight of lentil (Figure 13 and Appendix VIII). Numerically the higher (22.20 cm) weight was found at 45 cm residue retention and lower (20.96) was at 15 cm residue retention. Similar result was found Feizabady (2013).

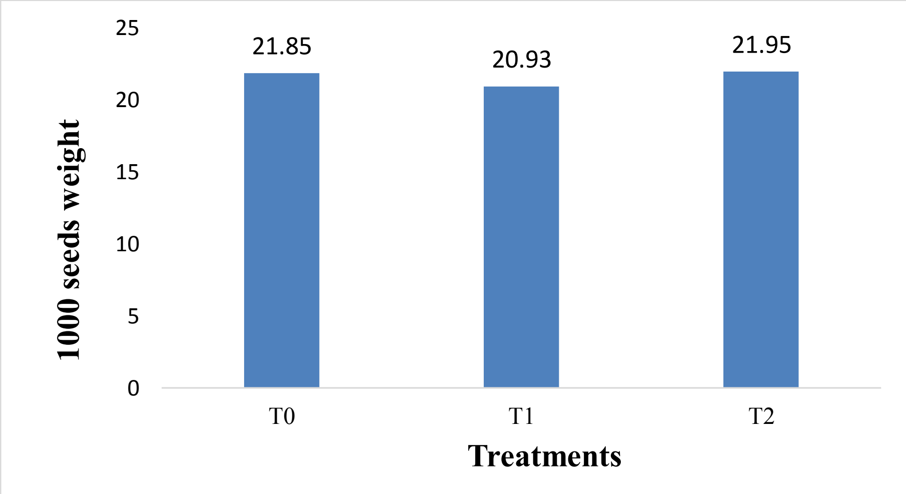


R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 13. Influence of rice residue retention on 1000 seeds weight of BARI Masur - 7

4.3.3.2 Effect of different tillage

There was no significant differences on 1000 seeds weight of lentil at different tillage (Figure 14 and Appendix VIII). Numerically the highest 1000 seeds weight (21.95) was found at strip tillage and lowest (20.93) was at conventional tillage. Similar result was found by Ranjbar (2014).



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 14. Influence of different tillage on 1000 seeds weight of BARI Masur - 7

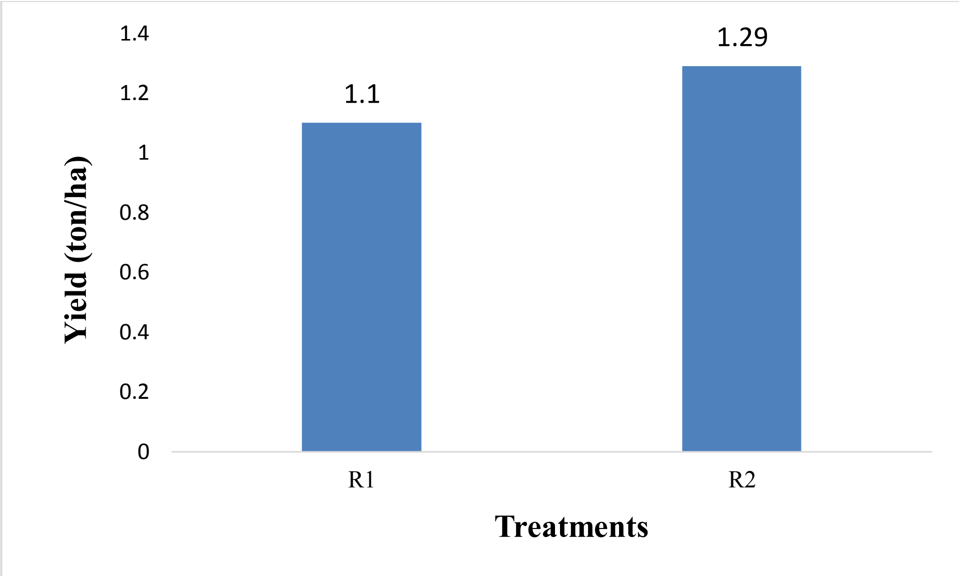
4.3.3.3. Interaction effect of rice residue retention and different tillage

Interaction effect between rice residue retention and different tillage was not found in respect of 1000 seeds weight of lentil (Table 5 and Appendix VIII). Numerically the higher (22.50) weight was found at 45 cm residue retention + zero tillage and lower (19.7) was at 15 cm residue retention + conventional tillage. Similar result was published by Jahkar *et al*. (2018).

4.3.4 Seed yield ton hectare^{-1}

4.3.4.1. Effect of rice residue retention

Seed yield was significantly influenced by the rice residue retention (Figure 15 and Appendix VIII).



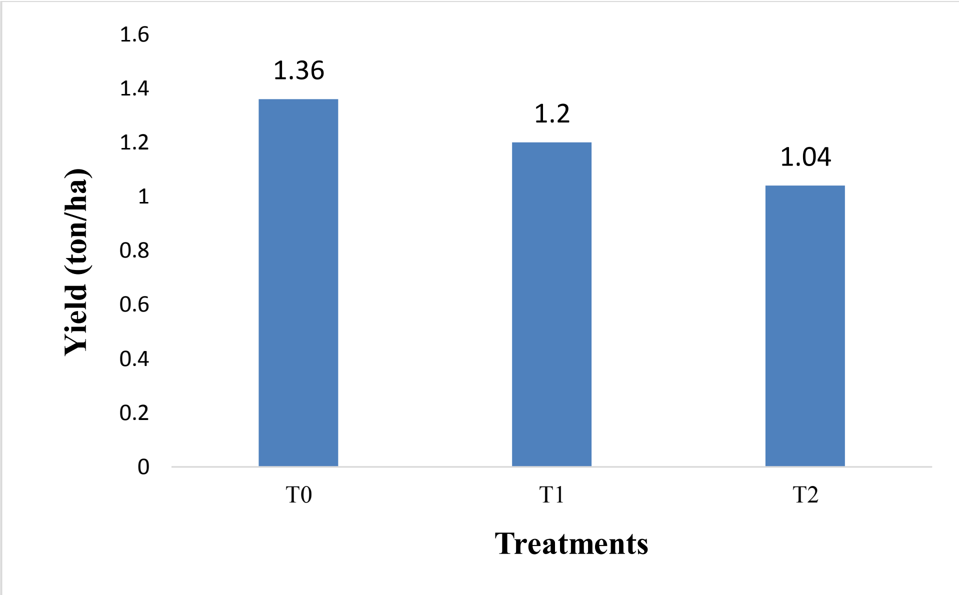
R_1 = 15 cm residue retention, R_2 = 45 cm residue retention

Figure 15. Influence of rice residue retention on yield of BARI Masur– 7

The highest seed yield (1.29 ton/ha) was obtained from the 45 cm residue retention and the lowest (1.11 ton/ha) was produced by 15 cm residue retention. This result is the agreement of several findings. Feizabady (2013) revealed that, the effect of maximum returning crop residue to soil on crop economic yield are increase. Jakhar *et al*. (2018) reported that higher crop residue (4 tones/ha) gave significantly higher seed yield of crop. Liu *et al*., (2007) published, generally, the seed yield of crop when maize residues are retained is greater than when residues are removed.

4.3.4.2. Effect of different tillage

Different tillage had significant effect on yield of lentil (Figure 16 and Appendix VIII). Zero tillage produced significantly the highest yield (1.36 ton/ha) and the lowest (1.04 ton/ha) yield was from strip tillage. Zero tillage conserve higher soil moisture and nutrient uptake by the crop and hence positive physiological andmetabolic activities and reproductive development of crop were probably influenced by increased tillage practices. Zero tillage practice influences favourably the soil-water-plant ecosystem, thereby affecting crop yields and quality. Ardell *et al.* (2000). Kilic (2015) reported minimum tillage increase the yield of leguminous crop because of swallow root system.



T_0 = Zero tillage, T_1 = Conventional tillage and T_2 = Strip tillage

Figure 16. Influence of different tillage on yield of BARI Masur - 7

4.3.4.3. Interaction effect of rice residue retention and different tillage

Interaction between rice residue retention and different tillage played an important role for promoting the yield of lentil. Yield was significantly influenced by the interaction effect (Table 5 and Appendix VIII). Among the treatments, the highest yield (1.47 ton/ha) was observed in 45 cm residue retention + zero tillage. The lowest yield (2.467 kg) was observed in 15 cm residue retention + strip tillage. Jakhar *et al*. (2018) reported that, zero tillage with 4 ton/ha residue retention had favorable effect on crop as it conserved more moisture in the soil profile during early growth period. Meena (2015) reported zero tillage + residue retention increase leguminous crop yield 33 % compared to zero tillage without residue retention.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

The field experiment was conducted at the Pulses Research Sub-station of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, during the period from November, 2016 to March, 2017 to study the soil moisture condition, growth and yield of lentil with different rice residue retention and tillage under the Modhupur Tract (AEZ-28). The experiment consisted of two factors as two residue retention viz., 15 cm residue retention (R_1**),** 45 cm residue retention (R_2**)** and three tillage system viz., Zero tillage (T_0**),** Conventional tillage (T_1), Strip tillage (T_2). The experiment was laid out in Randomized Complete Block design (RCBD) with three replications.

The data on soil moisture, crop growth parameters like plant height, number of branches plant^{-1} and dry weight plant^{-1}were recorded at different growth stages. Yield parameters like number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seeds weight and seed yield were recorded at harvest period. Data were analyzed using MSTAT-C package. The mean differences among the treatments were compared by least significant difference test at 5% level of significance.

Results showed that rice residue retention had significant effect on soil moisture, growth and yield parameters except 1000 seed weight. Higher soil moisture content was recorded at initial stage, 40 DAS, 60 DAS and harvest period with 45 residue retention (12.91, 13.20, 11.93 and 18.11 % respectively) due to heavy rainfall. The rapid increase of plant height was observed from 60 to 80 DAS of growth stages which was higher in the 45 cm residue retention compared to the 15 cm residue retention. However, at 20, 40, 60 and 80 DAS, 45 cm residue retention produced the tallest plant (15.71, 22.58, 31.14 and 34.20 cm respectively) and the lowest plant height was observed in 15 cm residue retention (12.22, 15.92, 29.07 and 31.94 cm respectively). The higher number of branches plant^{-1} at all the growth stages was found 45 cm residue retention but there was not any significant difference at 40 DAS. The dry weight plant^{-1} also higher in 45 cm residue retention at all the growth stages and there was not any significant difference at 40 DAS. The highest number of pods per plant, seeds per pod and yield were obtained from 45 cm residue retention.

Different types of tillage also significantly influenced soil moisture, growth and yield attributes. The results revealed that zero tillage preserved the maximum moisture of soil and strip tillage preserved low moisture content of soil. Strip tillage produced the tallest plant at all the growth stages and zero tillage produced the smallest plant at harvest. The highest number of branches per plant, dry weight, pod per plant, seed per pod and yield were obtained from zero tillage and lowest were from strip tillage and there was not any significant difference in 1000 seeds weight.

Interaction effect of residue retention and different tillage also significantly affected all parameters like moisture(%), growth and yield characters except 1000 seeds weight. 45 cm residue retention + zero tillage preserved maximum soil moisture and 15 cm residue retention + strip tillage preserved lower soil moisture. The tallest plant was found in 45 cm residue retention + strip tillage at 80 DAS and harvest period; and 45 cm residue retention + conventional tillage at 40 and 60 DAS. The lowest plant height was observed with 15 cm residue retention + zero tillage at 80 DAS and harvest period; and 15 cm residue retention + conventional tillage gave lowest height at 40 and 60 DAS. The highest number of branches, dry weight, pod per plant, seed per pod and yield were found from 45 cm residue retention + zero tillage and lowest were 15 cm residue retention + strip tillage.

CONCLUSION

Based on the results of the present study, the following conclusions may be drawn-

1. Maximum soil moisture was observed in Zero tillage.
2. The highest number of pods and yield was observed in 45 cm residue retention.
3. Zero tillage gave the highest number of pods and seed yield.
4. The highest seed yield and most of the yield contributing characters were observed in 45 cm residue retention + zero tillage.

However, to reach a specific conclusion and recommendation the same experiment need to be repeated and more research work should be done over different Agro-ecological zones.

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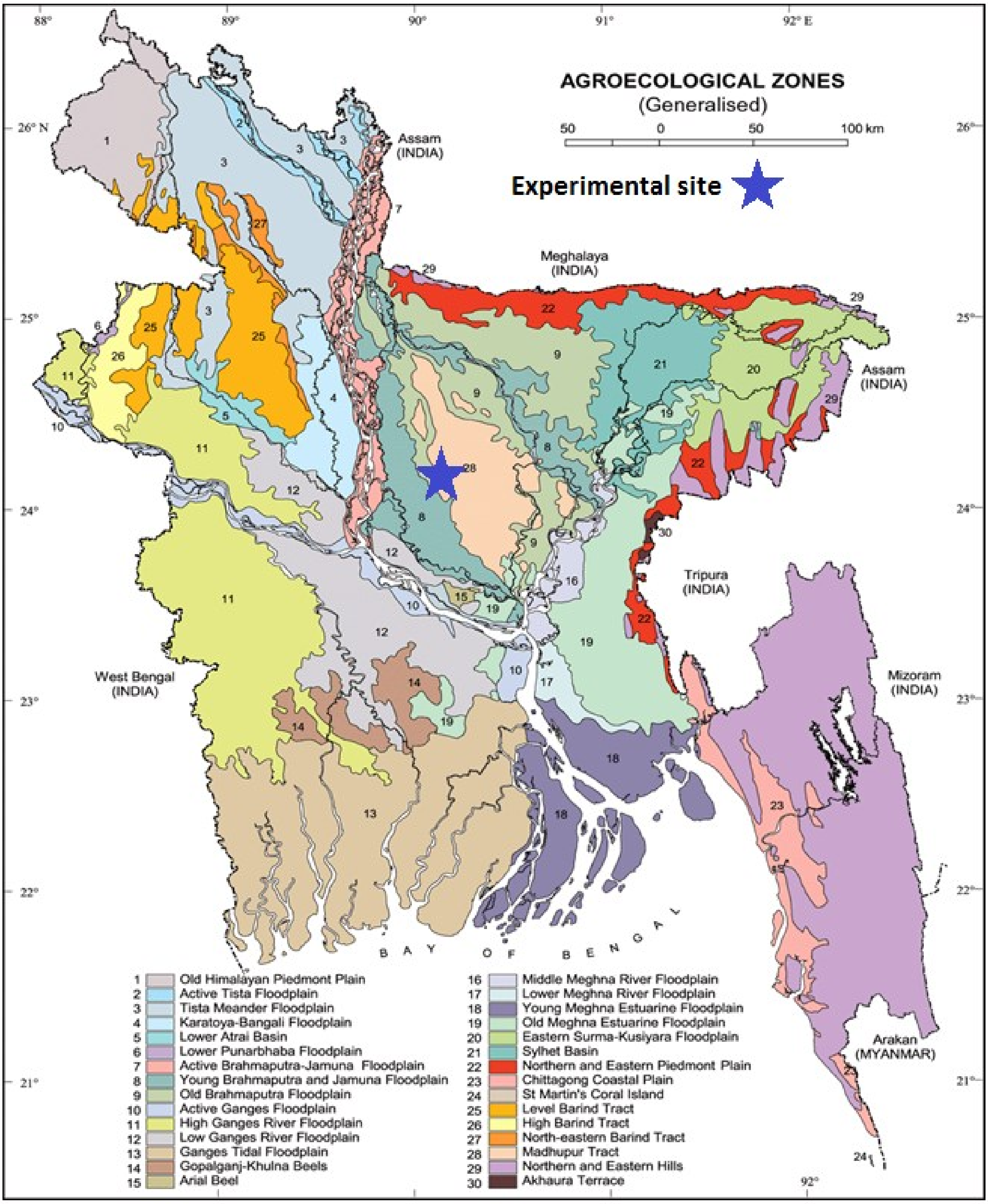
Appendices

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from November 2016 to April 2017

Months	Maximum temperature (c^0)	Minimum temperature (c^0)	Relative humidity at 12 pm (%)	Rainfall (mm)
November 2016	33	15	77	10.2
December 2016	29	14	84	63.9
January 2017	27	9	81	0
February 2017	33	13	70	3.2
March 2017	35	16	65	34.1
April 2017	35	20	74	327.1

Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. Mean square values for Soil moisture content at different days

Source of variation	Degrees of freedom	Soil moisture content at			
		Initial	40 DAS	60 DAS	Harvest
Replication	2	0.15	0.014	0.2	0.871
Residue retention	1	1.456**	1.439**	2.311**	13.005**
Tillage	2	0.773**	0.732*	3.151**	22.424**
Interaction	2	0.092*	0.067**	0.296**	0.502**
Error	10	0.085	0.1	0.061	1.439

**Significant at 1 % level

* Significant at 5 % level

Appendix IV. Mean square values for plant height of BARI Masur – 7 at different days after sowing

Source of variation	Degrees of freedom	Plant Height of BARI Masur– 7 at			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	0.732	4.155	2.22	4.061
Residue retention	1	54.776**	199.334**	19.323**	22.894**
Tillage	2	2.332**	1.815	9.93**	57.661**
Interaction	2	15.304**	5.987**	1.169*	2.461**
Error	10	0.567	0.958	0.973	0.674

** Significant at 1 % level

* Significant at 5 % level

Appendix V. Mean square values for number of branches per plant of BARI Masur – 7 at different days after sowing

Source of variation	Degrees of freedom	Number of branches of BARI Masur – 7 at			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	0.012	0.178	0.002	0.02
Residue retention	1	0.339	1.914**	2.722**	34.445**
Tillage	2	0.708**	4.733**	7.047**	9.532**
Interaction	2	0.015*	0.006**	0.036**	0.072**
Error	10	0.006	0.03	0.059	0.155

** Significant at 1 % level

* Significant at 5 % level

Appendix VI. Mean square values for dry weight per plant of BARI Masur – 7 at different days after sowing

Source of variation	Degrees of freedom	Dry weight of BARI Masur – 7 at			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	0.004	0.044	0.005	0.041
Residue retention	1	0.067	1.681**	5.173**	17.602**
Tillage	2	0.016	0.969**	1.36*	0.994**
Interaction	2	0.013	0.616**	1.308*	0.021**
Error	10	0.008	0.081	0.214	0.045

** Significant at 1 % level
*   Significant at 5 % level

Appendix VII. Mean square values for number of pods per plant and seeds per pod of BARI Masur – 7

Source of variation	Degrees of freedom	Number of pod/plant	Number of seed/pod
Replication	2	1.167	0.002
Residue retention	1	410.889**	0.315**
Tillage	2	266.667**	0.211**
Interaction	2	1.556**	0.044*
Error	10	19.633	0.015

** Significant at 1 % level
*   Significant at 5 % level

Appendix VIII. Mean square values for 1000 seed weight and seed yield of BARI Masur – 7

Source of variation	Degrees of freedom	1000 seeds weight	Seed yield
Replication	2	0.136	0.002
Residue retention	1	6.969	0.151**
Tillage	2	1.884	0.147**
Interaction	2	2.347	0.007**
Error	10	0.499	0.006

** Significant at 1 % level

*   Significant at 5 % level