



Effect of tillage intensity, fertilizer and cowdung on soil water conservation, yield and protein content of wheat

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Abstract

An experiment was carried out at the Bangladesh Agricultural University Farm under the Department of Soil Science during the winter season to study the effect of tillage intensity, fertilizer and cowdung on soil water conservation, yield and protein content of wheat. The experiment was laid out in a split-plot design with three tillage treatments (T₁, T₂ and T₃) in the main plots and fertilizer with cowdung treatments in the sub-plots and replicated thrice. The total numbers of plots were 18. The highest soil moisture content (41.40%) was found at 50 DAS (days after sowing) under T₂ tillage treatment and the lowest soil moisture content (31.79%) was found at 10 DAS under T₁ tillage treatment. On the other hand, the highest soil moisture content (40.16%) was found at 50 DAS under FCD treatment. The highest spike length (10.53 cm), number of spikelets spike⁻¹ (18.33), number of grains spike⁻¹ (43.63) and 1000-grain weight (44.82) were recorded in T₃ tillage treatment whereas the highest number of effective tillers plant⁻¹ (3.87) was found under T₂ tillage treatment. The highest grain yield of 3.75 t ha⁻¹ was recorded in T₃ tillage treatment and the lowest grain yield of 3.28 t ha⁻¹ was obtained under T₁ tillage treatment. The highest protein content in grain (10.85%) was recorded in T₃ tillage treatment and the lowest protein content in grain (9.41%) was found in T₁ tillage treatment. These results suggest that tillage operation and cowdung conserve moisture content that helps increase the availability of more nutrients for plant growth and thus increases crop yield.

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Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world. Wheat ranks first both in acreage and production of the world (UNDP and FAO, 1988). A major portion of world population lives on wheat for their subsistence. In Bangladesh, it is the second most important staple food crop after rice (Razzaque and Hossain, 1991). In some countries, it is the main food item. It contains 14% protein, 2.1% fat, 2.1% mineral matter and 78.11% starch (Peterson, 1965). It has significant role in human nutrition.

Wheat production has been declining over recent years, from 1.51 million tons in 2002-03 to 0.844 million tons in 2007-08 (BBS, 2008). The area planted to wheat in 2007-08 has declined by 3.0 percent compared to 2006-07 and by 30.5 percent compared to average of five years and the land was planted instead of Boro (BBS, 2008). The main reason for the decline in wheat area is weather, which in recent years has been blamed for low yields. If low temperatures are prolonged in the winter season, the yield of wheat is increased. If winter is short the yield declines because of the temperature sensitivity of this crop. The winter season in 2007-08 had a long cool period for which wheat yield had improved at 2.18 t ha⁻¹ compared to 1.84 t ha⁻¹ the previous year, resulting in an increase of production of almost 15 percent above the previous year's harvest (BBS, 2008).

Environmental factors strongly influence wheat yield, particularly grain yield, soil moisture and N, the former of which depends on irrigation water and its distribution during the growing season (Copper *et al.*, 1987). Typically in the past wheat-fallow (one crop in two years) has been cropping system used extensively in an irrigated farming system. This management system was designed to enhance water storage, in order to ensure emergence and establishment of the wheat seedling. Tillage operations are necessary to remove weeds and prevent crust formation (Aase and Siddoway, 1982). Tillage is considered to be oldest, most fundamental farm activity and first step for crop

production.

The magnitude of tillage effects varies with use of tillage implements. Power tiller is used for deep ploughing, sub soiling rotating the soil to make better than that of country plough. Hand tillage increases the soil moisture content. As a result soil becomes permeable, aerated and has a good physical condition for crop production. The advantages of different tillage systems are moisture conservation, reduction of soil erosion, less labour and energy requirement, more timely planting of crops and increased intensity of land use (Asoegwu, 1992).

The European community agricultural policy has strongly encouraged conservation tillage practices in order to decrease soil loss (European Union, 2000). No tillage management can increase both water use efficiency and wheat grain yield under dry land conditions (Bonfil *et al.*, 1999).

Balance fertilization is prerequisite for obtaining optimum potential yield. Namibair (1991) viewed that combined use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production but also in maintaining better soil fertility.

Wheat quality is also influenced by the interaction of a number of other factors including cultivar, soil, climate, cropping practices and grain storage conditions (Blumenthal *et al.*, 1991 and Borghi *et al.*, 1996), while an excess of soil moisture can lead to a decrease in grain protein content (Robinson *et al.*, 1979). Grain protein content is the result of complex interactions between N and water availability, yield and temperature.

Considering the above fact, the present investigation was taken under involving tillage intensity, fertilizer and cowdung with the changes in moisture content or in other word water conservation in the soil due to tillage intensity as well as fertilizer and cowdung application, to investigate the effect of tillage intensity, fertilizer and cowdung on the yield

contributing characters, yield and grain protein content of wheat and to examine the relationship between yield contributing characters and yield of wheat.

Materials and methods

Location of the experimental field

The experiment was conducted during the winter (Rabi) season and the experimental field is located at 24° 54' latitude and 90° 50' E longitude at a height of 18 m above the mean sea level. The soil belongs to the "Old Brahmaputra Floodplain" Agro-Ecological Zone-9 (FAO and UNDP, 1988).

Climate

The climate of the area is being experienced relatively high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season and low temperature and low humidity during rabi season.

Morphological characteristics of the experimental field

The soil lies under the fairly level Sonatola soil series. The General Soil Type is Noncalcareous Dark Grey Floodplain Soil and moderately well drained. Firmness is friable when dry and the cropping pattern is fallow-wheat. The physical properties of sand, silt and clay is 25.64, 66.00 and 8.36 and the particle density is 2.55 gcm⁻³ which belongs to silt loam textural class.

Test crop

The recommended high yielding wheat variety, Shatabdi was used as a test crop and recommended to cultivate in winter season. The variety performs well under late planting conditions. Maturity comes within 105-112 days. The yield under favorable conditions is 3.6-5.0 t ha⁻¹. It is resistant to leaf rust.

Land preparation

The land was first ploughed with the help of a power tiller and it was further ploughed with laddering as per as tillage treatment to prepare finally for sowing seeds of wheat. All sorts of weeds were removed by

hand from the field before sowing of wheat seeds.

Experimental design

The experiment was laid out in a split-plot design. There were two sets of experimental treatments viz. (i) three tillage treatments arranged as main plot and (ii) fertilizer and cowdung treatments were allocated into the two sub-plots. The treatments were replicated three times. Thus, the total numbers of plots were eighteen. The unit plot size was 4 m x 2.5 having spacing of plot to plot 0.5 m and block to block 1.0 m.

Treatment, Rates, Source and nutrient content of fertilizers and cowdung

The experiment was laid out in a split-plot design with three tillage treatments in the main plots and fertilizer with cowdung treatments in the sub-plots and replicated thrice. The tillage treatments were: one passing of a power tiller (T₁), two passing of a power tiller (T₂) and three passing of a power tiller (T₃). Fertilizer and cowdung treatments were: recommended dose of fertilizer @ 100 kg N(Urea 46%N) ha⁻¹, 75 kg K(MP 50%K) ha⁻¹, 25 kg P(TSP 20%P) ha⁻¹, 13 kg S(Gypsum 18%S) ha⁻¹, 2 kg Zn(Zinc oxide 78% Zn) ha⁻¹, 1 kg B(Boric acid 17%B) ha⁻¹ (F) and 60% of F + cowdung @ 5 t ha⁻¹ (1.13%N, 0.27%P, 1.18%K, 0.15%S and 58 ppm Zn)(FCD).

Main plot treatments Sub plot treatments

T₁ = 1 passing of a power tiller F = Recommended dose of fertilizers.

T₂ = 2 passing of a power tiller @100kg N, 18kg P, 50kg K, 20kg S.

T₃ = 3 passing of a power tiller 3kg Zn and 1kg B ha⁻¹ (BARC, 2005).

FCD = 60% of F + cowdung @ 5t ha⁻¹.

Rates, sources and nutrient content of fertilizers and cowdung

The name, rates and sources of the cowdung and fertilizers used in the experiments are shown in the

Table 1.

Cowdung and fertilizers application

The total amount of cowdung, TSP, MP, gypsum, zinc oxide and boric acid was applied during final land preparation but urea was applied in three equal splits. The first split was applied during final land preparation, the second split at heading growth stage and the third split at panicle initiation growth stage. Cowdung was applied in the plot and mixed with the soil by spade before sowing of wheat seed.

Sowing of seeds

Seeds of wheat were sown @ 120 kg ha⁻¹ in lines and covered by soil by hand. The line to line distance was 20 cm and the depth of furrow was about 6 cm. A strip of wheat crop was established around the experimental field as border crop.

Intercultural operations

For ensuring and maintaining the normal growth of the crop, intercultural operations were done. The following intercultural operations were done.

Irrigation

Two irrigations were applied, one being 21 days after sowing at crown root initiation (CRI) stage and second being 52 days after sowing at heading stage.

Weeding

Uprooting and removing of weeds were done one time from the field during the experimental period to control the obnoxious weeds.

Harvesting

The crop was harvested on at full maturity. For data collection, ten plants from each subplot were sampled randomly. The crop was cut at the ground level. Threshing, cleaning, and drying of grain were done separately subplot wise. The weight of grain and straw was recorded plot wise.

Data Collection for plant sample

Ten plants were randomly selected from each subplot at maturity to keep records on the yield contributing

characters like plant height, number of tillers plant⁻¹, spike length, number of spikelets spike⁻¹, and number of grain spike⁻¹ and weight of 1000 grains. The grain and straw yields were recorded and expressed as t ha⁻¹ and 1000 grains in g on 14% moisture basis. The grain was kept for protein determination. Data were collected from the following way:

Plant height

The plant height was measured from the ground level to top of the spike in cm. From each plot 10 plants were measured and averaged.

Number of effective tillers plant⁻¹

Ten plants were selected randomly from each plot and total number of effective tillers plant⁻¹ were counted and averaged.

Spike length

Length of spikes in ten selected plants per plot were recorded in cm and averaged.

Number of spikelets spike⁻¹

Total number of spikelets spike⁻¹ were counted and averaged from ten randomly selected plants from each plant.

Number of filled grains spike⁻¹

Each spike was selected and the filled grains spike⁻¹ were recorded and averaged. 1000 -grain weight
Thousand grains were randomly collected from each plot and the weights were recorded in g on 14% moisture basis in an electrical balance.

Grain and straw yield

Grain and straw obtained from each plot were dried and weighed carefully and the results were recorded and expressed as t ha⁻¹ on 14% moisture basis.

Collection and preparation of initial soil sample for physical analysis

The initial soil sample was collected before final land preparation from the plough depth layer (0-15cm). The samples were taken by means of an auger from 18 different random spots covering the whole

experimental plots. The soil samples were mixed thoroughly to make a composite sample and the unwanted materials such as stubble; weeds etc. were removed from soil. The composite soil sample was air dried ground and sieved through a 10-mesh sieve. This composite soil sample was stored in a clean plastic container for physical analysis.

Methods of soil analysis

The results have been presented in Table 2. The soil was analyzed following standard methods as follows.

Physical analysis of soil sample

Particle size distribution

Particle size analysis of soil was done by hydrometer method (Black, 1995). Fifty grams of air dry soil were taken in a dispersion cup and 10 ml of 5% calgon solution was added to the samples and allowed to soak for 15 minutes. Ninety milliliters distilled water was added to the cup. The suspension was then stirred with an electrical stirrer for 10 minutes. The content of the dispersion cup was then transferred to 1 liter sedimentation cylinder and distilled water was added to make the volume up to the mark. A cork was placed on the mouth of the cylinder and the cylinder was inverted several times until the whole soil mass appeared in the suspension. The cylinder was set upright and the hydrometer reading was taken at 40 seconds and 2 hours of sedimentation. The temperature of the suspension was also recorded with a thermometer at 40 seconds and 2 hours of sedimentation.

The correction of hydrometer reading was made as the hydrometer was calibrated at 68°F. The percentage of sand, silt and clay were calculated as follows:

$$\%(\text{silt} + \text{clay}) = \frac{\text{C.H.R. after 40 seconds of sedimentation}}{W} \times 100$$

$$\% \text{clay} = \frac{\text{C.H.R. after 2 hours of sedimentation}}{W} \times 100$$

$$\% \text{ sand} = 100 - \% (\text{ silt} + \text{ clay})$$

$$\% \text{ silt} = \% (\text{ silt} + \text{ clay}) - \% \text{ clay}$$

C.H.R. = Corrected hydrometer reading

W = Weight of soil.

The textural classes were determined by plotting the values of percentages of sand, silt and clay content on to the Marshall's Triangular Coordinate following USDA system.

Particle density

Particle density of initial soil was determined by volumetric flask method (Black, 1965). The particle density was determined by using the following formula.

$$\text{Particle density} = \frac{\text{Weight of soil solid}}{\text{Volume of soil solid}} \text{ g cm}^{-3}$$

Soil moisture

The soil moisture was determined by gravimetric method and was calculated by using following formula:

$$\text{Soil moisture (\%)} = \frac{W - W_1}{W_1} \times 100 \text{ (mass basis)}$$

Where, W = Weight of moist soil (g)

W₁ = Weight of oven dry soil (g)

Protein determination from grain

Preparation of sample

The plant samples were dried in an oven at 65° C for about 48 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The ground plant materials (grains) were stored in paper bags.

Digestion of samples with H₂SO₄

An amount of 0.1 g oven dried ground sample was taken into a 100 ml Micro-Kjeldhal flask. 1.1g catalyst mixture (K₂SO₄:CuSO₄.5H₂O: Se=100:10:1), 2 ml 30% H₂O₂ and 3 ml conc. H₂SO₄ were added into the flask. The flask was swirled and allowed to stand for about 10 minutes; followed by heating at a temperature raised slowly to 200°C. Heating was continued until the digest became clean and colorless. After cooling, it was taken into a 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. This digestion was performed for the N as well as

protein determination.

Calculation of protein content in wheat grain

The total N content from digest was first determined from wheat grain by similar method as described in soil analysis. The protein content in wheat grain was estimated multiplying of the nitrogen content in the grain sample with 6.25.

Correlation and regression analysis

Correlation and regression among soil properties, yield components and yields were studied.

Statistical analysis

Data on different parameters under study were statistically analyzed to ascertain the significance of the experimental results. The means for all the treatments were calculated and analyses of variance of all the characters studied were performed by DMRT (Duncan's Multiple Range Test). The significance of the difference between the pair of means was evaluated at 5% level of significance by least significant Difference (LSD) test using MSTAT-C

computer package program (Gomez and Gomez, 1984).

Results and discussion

Effect of tillage intensity, fertilizer, cowdung and their interaction on soil moisture content during growing season of wheat

The tillage intensity influenced soil moisture content significantly at 1% level of probability. The soil moisture ranged from 31.79% to 41.40%. The highest soil moisture content (41.40%) was found at 50 DAS under T₂ tillage treatment and the lowest moisture content (31.79%) was found at 10 DAS under T₁ tillage treatment (Table 2.). Soil moisture content is low in no tillage. The results indicated that the more loose soil absorbed more soil moisture compared to compacted soil. Wang *et al.* (1999) found that tillage intensity could preserve moisture than that of no tillage and interval tillage. The present findings are also agreement with Saltion and Mielniczeuk (1995). They reported that lower moisture content was found in sub-soil due to presence of hard plough pan.

Table 1. Rates, sources and nutrient content of cowdung and different fertilizers

Fertilizers and cowdung	Rates	Sources and nutrient content
N	100 kg N ha ⁻¹	Urea (46%N)
P	18 kg P ha ⁻¹	TSP (20%P)
K	50 kg K ha ⁻¹	MP(50%K)
S	20 kg S ha ⁻¹	Gypsum (18%S)
Zn	3 kg Zn ha ⁻¹	Zinc oxide (78% Zn)
B	1 kg B ha ⁻¹	Boric acid (17%B)
Cowdung	5 t ha ⁻¹	1.13%N,0.27%P,1.18%K,0.15%S and 58 ppm Zn

Application of cowdung also influenced soil moisture content significantly at different DAS except 30 DAS. The increasing effect was more where cowdung was applied. The moisture content ranged from 31.30% to 40.16% (Table 2.). The highest soil moisture content (40.16%) was found at 50 DAS under FCD treatment and the lowest moisture content (31.30%) was found at 10 DAS under F treatment. This might be due to addition of cowdung that has capability to conserve more water in soil. Addition of cowdung in soil increased the moisture holding capacity as a result soil moisture content was increased. Mikhailovskaya

and Batchilo (2007) reported that the use of organic manure increased soil moisture content at least 40%. Similar results were found by Sharma and Bali (2000) and Mbagwu (1997).

The interaction effect of tillage intensity, fertilizer and cowdung had influence on moisture content. The moisture ranged from 30.00% to 42.70% (Table 2.). The highest moisture content (42.70%) was found at 50 DAS under T₃FCD treatment combination and the lowest moisture content (30.00%) was found at 30 DAS under T₁FCD treatment combination.

Table 2. Effect of tillage intensity, fertilizer and cowdung on soil moisture content at 0-10 cm soil depth on growing season of wheat.

Treatments	% moisture (mass basis)				
	Days after sowing (DAS)				
	10	20	30	40	50
Tillage intensity					
T ₁	31.79b	32.95c	32.50b	33.06b	34.88b
T ₂	31.45b	34.05b	33.48ab	33.92b	41.40a
T ₃	32.55a	39.95a	34.45a	36.95a	40.23a
Level of significance	**	**	**	**	**
Lsd _(0.05)	0.57	0.53	1.64	0.78	0.26
Fertilizer and cowdung					
F	31.30b	37.37b	33.32	33.35b	37.51b
FCD	32.56a	33.93a	33.63	35.93a	40.16a
Level of significance	**	**	NS	**	**
Lsd _(0.05)	0.46	0.43	-	0.64	0.21
Tillage intensity × Fertilizer and cowdung					
T ₁ F	31.80b	34.30c	35.00a	30.22c	33.28e
T ₁ FCD	31.77b	31.60d	30.00b	35.90b	36.47d
T ₂ F	30.70c	37.70b	30.95b	31.54c	41.50b
T ₂ FCD	32.20b	30.40e	36.00a	36.30b	41.30b
T ₃ F	31.40bc	40.10a	34.00a	38.30a	37.75c
T ₃ FCD	33.70a	39.80a	34.90a	35.60b	42.70a
Level of significance	**	**	**	**	**
Lsd _(0.05)	0.80	0.74	2.32	1.11	0.36

Effect of tillage intensity, fertilizer, cowdung and their interaction on plant height at different growth stages of wheat

The plant height of wheat was significantly changed by different tillage treatments (Table 3). The analysis of variance (ANOVA) for plant height at different

tillage treatments of the experiment, shows significant variation at different growth stages except 35 and 55 DAS. At 25 DAS, plant height ranged from 20.42 to 22.11 cm. The tallest plant (22.11 cm) was recorded under T₃ treatment and the shortest plant (20.42 cm) was found under T₂ treatment (Table 3).

Table 3. Effect of tillage intensity, fertilizer, cowdung and their interaction on plant height at different growth stages of wheat.

Treatments	Plant height (cm)					
	Days after sowing (DAS)					
	25	35	45	55	65	75
Tillage intensity						
T ₁	20.15b	25.40	34.38b	47.75	57.88b	90.15ab
T ₂	20.47b	24.08	38.17ab	46.58	64.30a	89.43b
T ₃	23.13a	25.42	38.88a	49.02	63.59a	93.95a
Level of significance	*	NS	**	NS	**	**
Lsd _(0.05)	0.548	-	1.15	-	2.58	0.54
Fertilizer and cowdung						
F	20.29b	24.40	37.40	46.76	60.62b	90.29b
FCD	21.94a	25.54	36.89	48.81	63.22a	92.07a
Level of significance	*	NS	NS	NS	**	**
Lsd _(0.05)	1.35	-	-	-	2.11	0.44
Tillage intensity × Fertilizer and cowdung						
T ₁ F	19.70	26.43a	33.60c	46.90	55.86d	90.70c
T ₁ FCD	21.93	24.37ab	35.17c	48.60	59.90c	89.60d
T ₂ F	19.37	22.47b	38.27b	43.97	61.80bc	87.67e
T ₂ FCD	21.47	25.70a	38.07b	49.20	66.80a	91.20c
T ₃ F	21.80	24.30ab	40.33a	49.40	64.21ab	92.50b
T ₃ FCD	22.42	26.54a	37.43b	48.63	62.97bc	95.40a
Level of significance	NS	*	**	NS	**	**
Lsd _(0.05)	-	2.66	1.63	-	3.65	0.77

At 75 DAS, plant height ranged from 89.43 to 93.95 cm. The tallest plant (93.95 cm) was found in T₃ treatment and the shortest plant (89.43 cm) was obtained in T₂ treatment (Table 3).

Plant height was significantly increased by the addition of cowdung. At 25 DAS, the tallest plant (21.94 cm) was found in FCD treatment and the shortest plant (20.29 cm) was found in F treatment (Table 3). At 75 DAS, the tallest plant (92.07 cm) was recorded in FCD treatment and the shortest plant (90.29 cm) was found under F treatment (Table 3).

The interaction of tillage intensity, fertilizer and cowdung significantly affected the plant height. At 25 DAS, the tallest plant (22.42 cm) was recorded in T₃FCD treatment combination and the shortest plant (19.37 cm) was found in T₂F treatment combination. At 75 DAS, tallest plant (95.40 cm) was obtained in T₃FCD treatment combination and the shortest plant (87.67 cm) was found under T₂F treatment combination (Table 3).

Effect of tillage intensity, fertilizer, cowdung and their interaction on the yield contributing characters and yield of wheat

Plant height at harvest stage

The plant height of wheat was significantly changed by different tillage treatments at 1% level of probability. The maximum plant height (91.43 cm) was recorded in T₁ treatment and the minimum plant height (90.87 cm) was found under T₃ treatment (Table 4). Plant height at harvest stage and grain yield were positively correlated ($r=0.482^*$) and statistically significant (Fig. 1).

The plant height of wheat was also significantly changed by the addition of fertilizers and cowdung at 1% level of probability. The maximum plant height (92.80 cm) was observed under FCD treatment. The shortest plant (89.40 cm) was found under F treatment (Table 4).

Table 4. Effect of tillage intensity, fertilizer, cowdung and their interaction on the yield contributing characters of wheat.

Treatments	Plant height (cm)	Effective tillers plant ⁻¹	Spike length (cm)	Spikelets spike ⁻¹	No. of grains spike ⁻¹	1000-grain weight (g)
Tillage intensity						
T ₁	91.43a	3.24b	9.82	17.27b	41.07	43.62
T ₂	91.00ab	3.87a	10.33	16.50c	40.97	44.62
T ₃	90.87b	3.69a	10.53	18.33a	43.63	44.82
Level of significance	**	**	NS	**	NS	NS
Lsd(0.05)	0.57	0.38	-	0.64	-	-
Fertilizer and cowdung						
F	89.40b	3.18b	9.77b	16.57b	39.36b	42.73b
FCD	92.80a	4.01a	10.69a	18.16a	44.42a	45.97a
Level of significance	**	**	**	**	**	**
Lsd(0.05)	0.47	0.31	0.65	0.52	4.05	2.00
Tillage intensity × Fertilizer and cowdung						
T ₁ F	89.80bc	3.01	9.23	16.20d	37.00	41.23
T ₁ FCD	93.07a	3.47	10.40	18.33b	45.13	46.00
T ₂ F	88.60c	3.27	10.00	16.27d	39.87	42.60
T ₂ FCD	93.40a	4.47	10.67	16.73cd	42.07	46.63
T ₃ F	89.80bc	3.27	10.07	17.25c	41.20	44.37
T ₃ FCD	91.93b	4.10	11.00	19.42a	46.07	45.27
Level of significance	**	NS	NS	**	NS	NS
Lsd(0.05)	0.65	-	-	0.90	-	-

The interaction effect of tillage, fertilizer and cowdung showed significant effects on plant height. It was clear that the tallest plant (93.40 cm) was obtained in T₂FCD treatment combination and the shortest plant (88.60 cm) was found in T₂F treatment combination (Table 4).

Number of effective tillers plant⁻¹

Tillage intensity showed on influence the number of effective tillers plant⁻¹ of wheat significantly at 1% level of probability. The highest number of effective tillers plant⁻¹ (3.87) was recorded in T₂ treatment and the lowest number of effective tillers plant⁻¹ (3.24)

was found under T_1 treatment (Table 4). Effective tillers plant^{-1} and grain yield were positively correlated ($r = 0.498^*$) and statistically significant (Fig. 2). It was possibly due to absorption of more water and nutrients from the deeper soil. This result is accorded with Ogbodo (2005).

The number of effective tillers plant^{-1} was also influenced by fertilizer and cowdung treatments at 1% level of probability. The maximum number of effective tillers plant^{-1} (4.01) was observed in FCD treatment while the minimum number of effective tillers plant^{-1} (3.18) was recorded in F treatment (Table 4). The present result is accorded with Reddy *et al.* (2004).

The interaction effect of tillage intensity, fertilizer and cowdung on the number of effective tillers plant^{-1} was not statistically significant (Table 4). The treatment combination T_2 FCD produced the highest number of effective tillers plant^{-1} (4.47) and the minimum number of effective tillers plant^{-1} (3.01) was recorded in T_1 F treatment combination (Table 4).

Spike length

The tillage treatment T_3 produced the highest spike length of wheat (10.53 cm) which was not statistically significant and the shortest spike length of wheat (9.82 cm) was recorded in T_1 tillage treatment (Table 4). Ogbodo (2005) reported that crop growth and yield increased with tilled soil over untilled soil. Spike length and grain yield were positively correlated ($r=0.632^{**}$) and statistically significant (Fig. 3).

Application of cowdung influenced on spike length of wheat at 1% level of probability. From the Table, it was observed that the maximum spike length of wheat (10.69 cm) was recorded under the FCD treatment and the minimum spike length of wheat (9.77 cm) was observed in the F treatment (Table 4). The interaction effect of tillage, fertilizer and cowdung was not significantly influenced the spike length of wheat (Table 4). The highest spike length of wheat (11.00 cm) was found under T_3 FCD treatment combination and the shortest spike length of wheat

(9.23 cm) was found under T_1 F treatment combination (Table 4).

Number of spikelets spike⁻¹

The tillage treatments influenced the number of spikelets spike^{-1} significantly at 1% level of probability. The maximum number of spikelets spike^{-1} (18.33) was found in T_3 treatment and the minimum number of spikelets spike^{-1} (16.50) was recorded in T_2 treatment.

Application of fertilizers and cowdung influenced the number of spikelets spike^{-1} at 1% level of probability. The maximum number of spikelets spike^{-1} (18.16) was recorded under the FCD treatment and the minimum number of spikelets spike^{-1} (16.57) was recorded in the F treatment (Table 4).

The interaction effect of tillage intensity, fertilizer and cowdung on spikelets spike^{-1} was also significant. The maximum number of spikelets spike^{-1} (19.42) was found under T_3 FCD treatment combination and the minimum number of spikelets spike^{-1} (16.20) was found under T_1 F treatment combination (Table 4).

Number of grains spike⁻¹

The highest number of grains spike^{-1} (43.63) was found under T_3 treatment. The lowest number of grains spike^{-1} (40.97) was recorded under T_2 treatment (Table 4).

Application of fertilizer and cowdung treatments influenced the number of grains spike^{-1} at 1% level of probability. The highest number of grains spike^{-1} (44.42) was observed in FCD treatment, which was significantly different from other treatments. The lowest number of grains spike^{-1} (39.36) was observed in F treatment (Table 4).

The interaction effect of tillage, fertilizer and cowdung was not significantly affected on grains spike^{-1} (Table 4). The highest number of grains spike^{-1} (46.07) was observed in T_3 FCD treatment combination and the lowest number of grains spike^{-1} (37.00) in T_1 F treatment (Table 4).

1000-grain weight

The highest 1000-grain weight of wheat (44.82 g) was found under T₃ treatment. The lowest 1000-grain weight of wheat (43.62 g) was observed in under T₁ treatment (Table 4).

Fertilizer and cowdung treatments influenced 1000-grain weight at 1% level of probability. The maximum 1000 grain weight (45.97g) was found under FCD treatment. The minimum 1000 grain weight (42.73 g) was found under F treatment (Table 4).

Interaction effect of tillage intensity, fertilizer and cowdung was not significantly influenced 1000-grain weight of wheat. The highest 1000-grain weight of wheat (46.63 g) was found under T₂FCD treatment combination. The minimum 1000-grain weight (41.23g) was found under T₁F treatment combination (Table 4).

Grain yield

Tillage intensity caused a significant influence in grain yield at 5% level of probability. The highest

grain yield of 3.75 t ha⁻¹ was found under T₃ treatment and the lowest grain yield of 3.28 t ha⁻¹ was obtained in T₁ treatment (Table 5). This finding was supported by Ranjan *et al.* (2006), Ogbodo (2005), Maecka and Blecharczyk (2002), Matin and Uddin (1994), Rejaul and Ahmed (1997) and Ardell *et al.* (2000).

Application of fertilizer and cowdung showed a significant influence on grain yield at 1% level of probability. The highest grain yield of 3.82 t ha⁻¹ was recorded under FCD treatment and the lowest grain yield of 3.26 t ha⁻¹ was recorded under F treatment (Table 5). This finding was supported by Tripathi *et al.* (2006), Reddy *et al.* (2004) and Saitoh *et al.* (2001).

The interaction effect of tillage, fertilizer and cowdung showed significant result for producing grain yield of wheat (Table 5). The highest grain yield of 4.07 t ha⁻¹ was found under T₃FCD treatment combination. The lowest grain yield of 3.17t ha⁻¹ was found under T₁F and T₂F treatment combinations (Table 5).

Table 5. Effect of tillage intensity, fertilizer, cowdung and their interaction on grain yield, straw yield and protein content of wheat.

Treatments	Grain Yield (t ha ⁻¹)	Straw Yield (t ha ⁻¹)	Grain protein (%)
Tillage intensity			
T ₁	3.28b	6.92c	9.41b
T ₂	3.58ab	7.33b	9.93ab
T ₃	3.75a	8.76a	10.85a
Level of significance	*	**	**
Lsd (0.05)	0.37	0.97	0.38
Fertilizer and cowdung			
F	3.26b	7.23b	9.44b
FCD	3.82a	8.11a	10.68a
Level of significance	**	**	**
Lsd(0.05)	0.30	0.79	0.31
Tillage intensity × Fertilizer and cowdung			
T ₁ F	3.17b	6.50b	8.06d
T ₁ FCD	3.40ab	7.33ab	10.75b
T ₂ F	3.17b	6.67b	10.56b
T ₂ FCD	4.00ab	8.00ab	9.29c
T ₃ F	3.43ab	8.51a	9.69c
T ₃ FCD	4.07a	9.00a	12.00a
Level of significance	**	*	**
Lsd(0.05)	0.53	1.37	0.48

Means followed by common letters do not differ significantly

NS= Not significant

** =Significant at 1% level of probability

DAS = Days after sowing.

Straw yield

Tillage intensity influenced the straw yield of wheat significantly at 1% level of probability. The highest straw yield of 8.76 t ha⁻¹ was recorded under T₃

treatment and the lowest straw yield of 6.92 t ha⁻¹ was found under T₁ treatment (Table 5). Application of fertilizer and cowdung showed significant result on the straw yield at 1% level of probability.

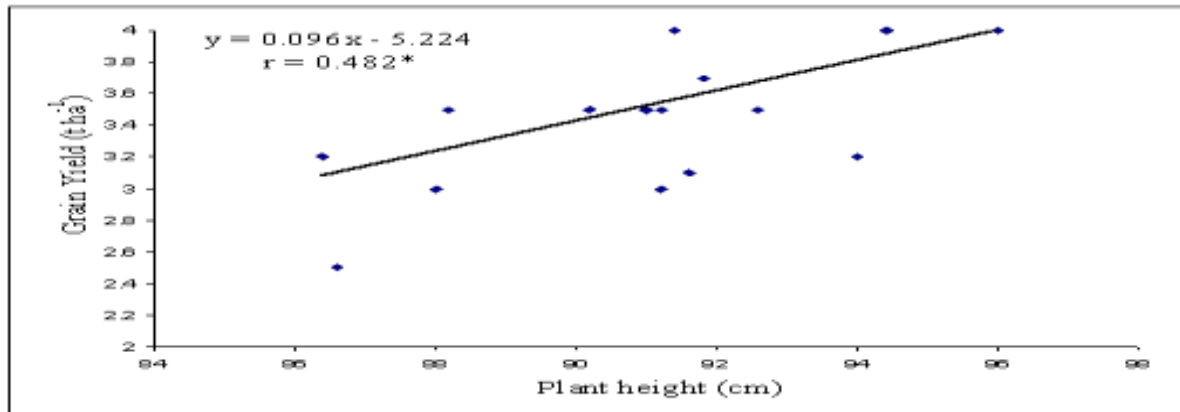


Fig. 1. Relationship between plant height and grain yield.

The highest straw yield of 8.11 t ha⁻¹ was recorded in FCD treatment and the lowest straw yield of 7.23 t ha⁻¹ was found under F treatment (Table 5).

straw yield of 6.50 t ha⁻¹ was observed under T₁F treatment combination (Table 5).

The interaction effect of tillage intensity, fertilizer and cowdung showed significant result on straw yield. The highest straw yield of 9.00 t ha⁻¹ was recorded under T₃FCD treatment combination. The lowest

Effect of tillage intensity, fertilizer, cowdung and their interaction on protein content of wheat grain
Tillage intensity influenced the protein content significantly at 1% level of probability.

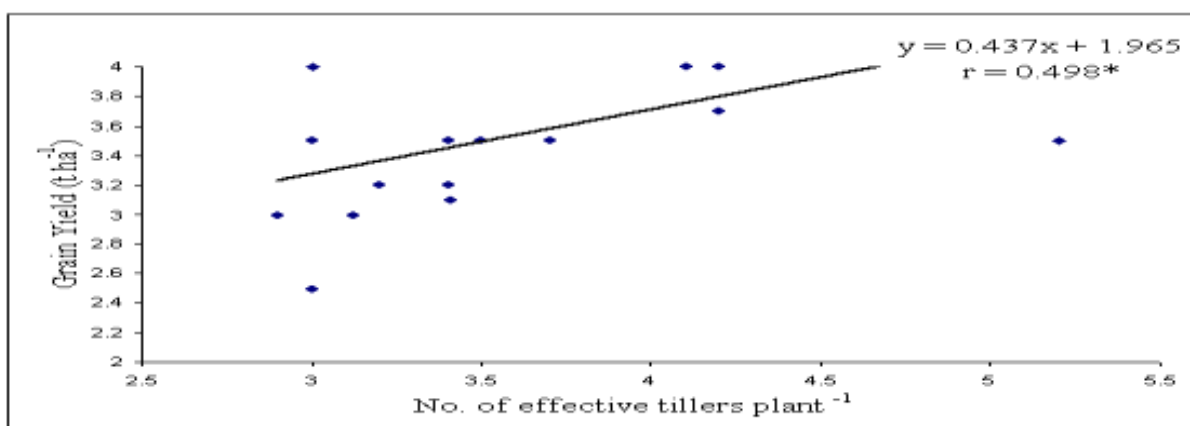


Fig. 2. Relationship between effective tillers plant⁻¹ and grain yield.

The highest protein content (10.85%) in grain was found in T₃ treatment. The lowest protein content (9.41%) in grain was obtained in T₁ treatment (Table 5). Vita *et al.* (2007) observed that the highest protein content was obtained under conventional tillage than no-tillage. Water stress is associated with increased grain protein content (Terman *et al.*, 1996), while an

excess of soil moisture can lead to a decrease in grain protein content (Robinson *et al.*, 1979). Grain protein content is the result of complex interactions between nitrogen and water availability, yield and temperature. Lopez-Bellido *et al.* (1998) reported higher grain protein content for conventional tillage than for no-tillage.

Application of cowdung significantly influenced protein content in grain of wheat at 1% level of probability. The highest protein content (10.68%) was found under FCD treatment and the lowest protein content (9.44%) was recorded under F treatment (Table 5).

The interaction effect of tillage intensity, fertilizer and

cowdung on the protein content was significant (Table 5). The highest protein content (12.00%) was found under T₃FCD treatment combination and the lowest protein content (8.06%) was recorded under T₁F treatment combination. Cremenscu *et al.* (1996) found that manure and organic fertilizers interaction increased grain protein content.

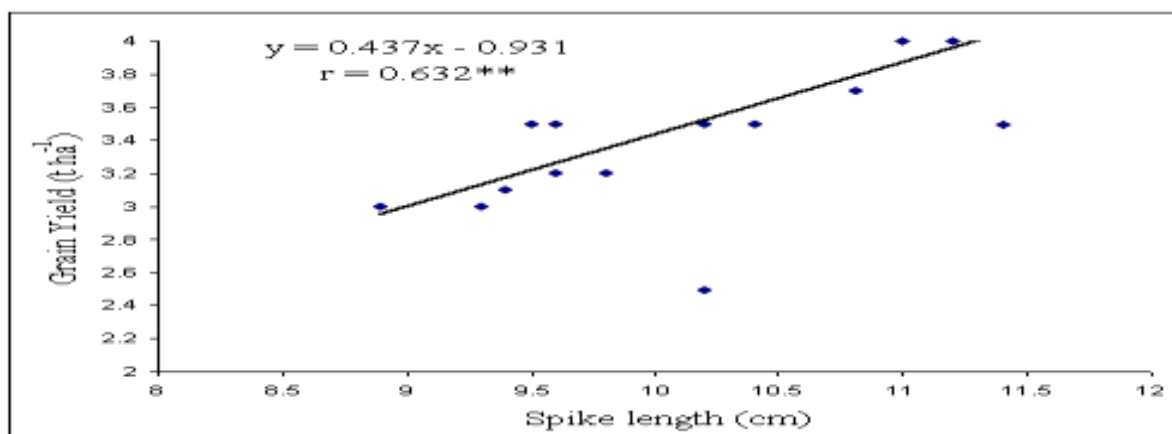


Fig. 3. Relationship between spike length and grain yield.

Correlation and regression analysis between grain yield and yield contributing characters of wheat

Correlation and regression equation show that grain yield has a significant positive correlation with plant height ($r = 0.482^*$), effective tillers plant⁻¹ ($r = 0.498^*$) and spike length ($r = 0.632^{**}$). The graphical representation between grain yield with plant height, effective tillers plant⁻¹ and spike length have been shown in Figures 1-3.

Summary and conclusion

Soil moisture was significantly influenced by tillage intensity, fertilizer and cowdung treatments. The highest soil moisture content (41.40%) was found at 50 DAS under T₂ tillage treatment and the lowest soil moisture content (31.79%) was found at 10 DAS under T₁ tillage treatment during growing season. At 25 DAS, the tallest plant (22.11 cm) was found under T₃ tillage treatment and the shortest plant (20.42 cm) was found under T₂ tillage treatment. The highest plant height at harvest stage (91.43cm) was found under T₁ tillage treatment. The highest spike length (10.53 cm), spikelets spike⁻¹ (18.33), number of grains spike⁻¹ (43.63) and 1000-grain weight (44.82 g) were

observed under T₃ tillage treatment. The highest number of effective tillers plant⁻¹ (3.87) was found under T₂ tillage treatment. On the other hand, the lowest plant height at harvest stage (90.87cm) was observed in T₃ tillage treatment. The lowest number of effective tillers plant⁻¹ (3.24), spike length (9.82 cm) and 1000-grain weight (43.62 g) were observed in T₁ tillage treatment. The lowest number of Spikelets spike⁻¹ (16.50) and grains spike⁻¹ (40.97) was observed in T₂ tillage treatment.

The application of fertilizer and cowdung treatments, the yield contributing characters of wheat responded significantly by tillage intensity. The highest plant height (92.80cm), number of effective tillers plant⁻¹ (4.01), spike length (10.69 cm), spikelets spike⁻¹ (18.16), number of grains spike⁻¹ (44.42) and 1000-grain weight (45.97 g) were recorded in FCD treatment and the lowest plant height (89.40cm), number of effective tillers plant⁻¹ (3.18), spike length (9.77cm), spikelets spike⁻¹ (16.57), number of grains spike⁻¹ (39.36) and 1000-grain weight (42.73 g) were observed in F treatment.

The highest grain yield of 3.75 t ha⁻¹, straw yield of 8.76 t ha⁻¹ and protein content (10.85%) were recorded in T₃ tillage treatment. The lowest grain yield of 3.28 t ha⁻¹, straw yield of 6.92 t ha⁻¹ and protein content (9.41%) were observed in T₁ tillage treatment. In case of application of fertilizer and cowdung treatments, the highest grain yield of 3.82 t ha⁻¹, straw yield of 8.11 t ha⁻¹ and protein content (10.68%) were observed in FCD treatment and the lowest grain yield of 3.26 t ha⁻¹, straw yield of 7.23 t ha⁻¹ and protein content (9.44%) were observed in F treatment. Based on the study the following conclusions may be drawn-Tillage intensity and cowdung with fertilizer application conserved more moisture in the soil; higher yields and protein content of wheat were recorded due to the tillage intensity, fertilizer and cowdung application; a positive relationship was found between yield contributing characters and yield of wheat.

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