World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org SJIF Impact Factor: 4.223

EFFECT OF LAND PREPARATION METHODS AND ANIMAL MANURE APPLICATION RATES ON SOIL MOISTURE CONSERVATION AND YIELD OF ONION (*Allium cepa*) AT GODE, SOMALI REGIONAL STATE, ETHIOPIA.

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Article Received on 24/11/2016 Article Revised on 13/12/2016 Article Accepted on 03/01/2017

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ABSTRACT

The Ethiopian economy is mainly agrarian. It employs 85% of the population and contributes 45% of the gross domestic product and 90% of the national export earnings but agriculture in Ethiopia is dominated by rainfed farming with low productivity specially dry land part of the country like Gode zone of Somali region. As a result, crops have severe moisture stress through their growth stages. Therefore, a field experiment was conducted at Gode ATVET College farm of sandy clay loam soil in the year 2012/13 to assess the effectiveness of different land preparation methods along with manure applications, enhancing soil moisture and thereby onion productivity. The experiment was arranged in a split plot design with three replications; tied ridging, broad bed and zero tillage being as the main plot factor and different levels of animal manure as sub-plot factor with the rates of 0, 3 and 6 tons /ha and therefore nine combined treatments were tested. The analysis of variance for the results of the study indicated that the significant differences were observed in soil bulk density, porosity and available moisture content due to different levels of animal manure applications. Soil moisture content at different soil depths at an interval of 15 days as well as vegetative parameters and yield component also showed a significant difference due to tied ridging and animal manure. Therefore, tied ridging with 6 tons of animal manure may be recommended to reduce the risk of moisture stress and to fetch a good yield in the study area.

KEYWORD: soil moisture, manure applications, yield of onion.

1. INTRODUCTION

In Ethiopia at present, different vegetable crops are produced in many home gardens and also commercially in different parts of the country (Fekadu and Dandena, 2006). The major producers of vegetable crops are small-scale farmers, production being mainly rain fed and few under irrigation (CSA, 2010). Vegetable crops production of individual peasant farmers is mainly for self-sufficiency in food and income.

Statistics on the production of onion in Ethiopia show that it is cultivated on about 17,588 ha and the national average yield is low 9.63 t ha^{-1} (CSA, 2010) as compared to world average of 17.30 t ha^{-1} (FA0, 2010). In Ethiopia, south eastern part of Somali region (Gode), the area under onion production is estimated to be about 6,000 ha from which 24,000 tones of onion was produced in 2009, with average yield of 4 t ha^{-1} (personal communication, Gode District Agricultural Office). This indicates that the country has low productivity to be benefited from onion production. Gode in Somali Regional State (SRS) has potential of producing some agricultural products such as maize mainly for animal feed and onion for the home consumption and local market due to the availability of irrigation water. But the agro pastoral farmers do not have knowledge on the benefits of using organic and inorganic fertilizers and soil moisture conservation practices to obtain maximum productivity in onion production. Lack of soil water conservation practice results in soil erosion by wind, adversely affect soil physical characteristics, storage and infiltration capacity of soil, root penetration difficulties, aeration problem, and essential nutrient loss for plant growth (Ayele Gebremariam, 2000).

So far, the research was done in Gode ATVET College farm, in the significance of the problems of soil moisture stress, leading to low crop productivity, lack research works on the effectiveness of different land preparation along with manure application, the difficulty of environmental condition, the problems of soil erosion and drought. Hence, to fill gaps in that direction, it is better to study the production system, and soil moisture conservation technique by different methods of land preparations (tillage) with different levels of animal manure. Thus, the study was conducted with the following objectives.

- To investigate the effects of land management practices along with different levels of farm yard manure application on soil moisture conservation and yield of onion.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted at Gode, in Somali Regional State located at 1225 km south east of Addis Ababa. The experimental site is situated at latitude of 5^o 95' - 6^o 12'N, longitude of 44^0 95' - 45^o 21' E and altitude of 295 meter above sea level.

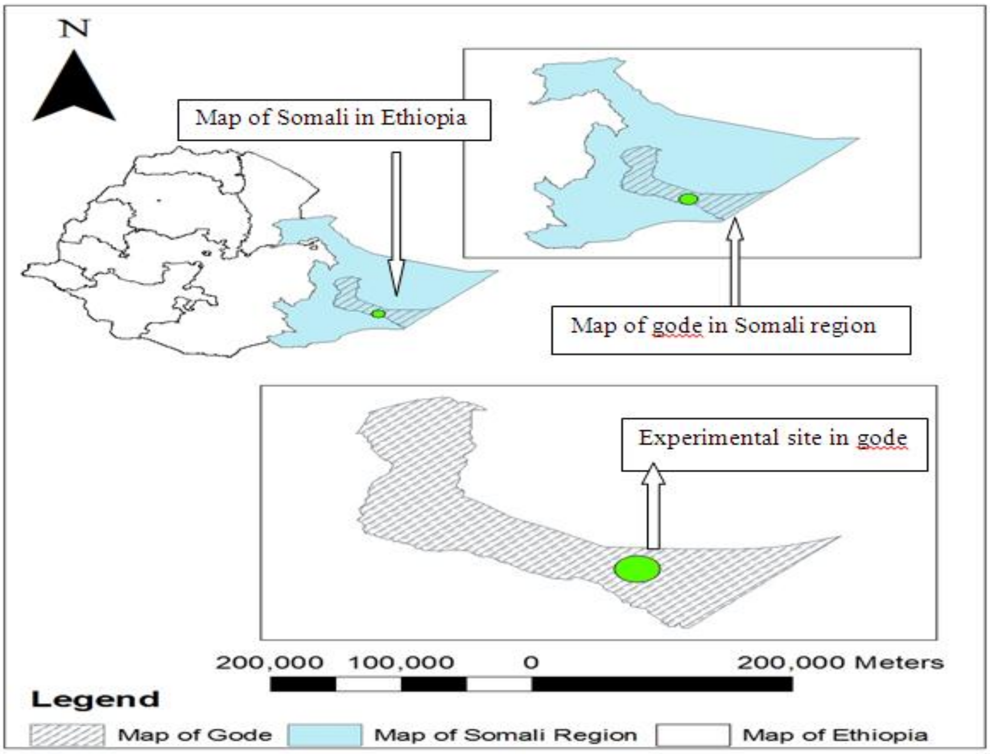

Figure 1: Location map of study area.

2.2. Treatments and Experimental Design

The experiment consists of nine treatment combinations and three replications arranged in split plot design. Of the nine combined treatments, the three main plot treatments of land preparation methods (tillage practice) considered in this experiment were zero tillage, tied ridging and broad bed tillage and the three different levels of animal manure used as subplots were without manure, 3 tons per hectare and 6 tons per hectare manure. The different treatments for the experimentation were assigned as zero tillage with zero level manure (T3t1), zero tillage with 3 tons of manure (T3t2), zero tillage with 6 tons of manure (T3t3), tied ridging with zero level manure (T2t1), tied ridging with 3 tons of manure (T2t2), tied ridging with 6 tons of manure (T2t3), broad bed with zero level manure (T1t1), broad bed with 3 tons of manure (T1t2) and broad bed with 6 tons of manure (T1t3).

Each treatment was applied on an effective plot size of 3.5m x 1.4m ($4.9m^2$) and separated by a distance of 1m between blocks and 1m within plots. The spacing between plants within a row, between rows and between ridges was 10, 20 and 40 cm respectively (EIAR, 2004). With these spacing, a plot constitutes of seven rows. For each plot, the middle three rows were used as sample row and all data were observed from there. The field layout of experiment is given in Figure 2.

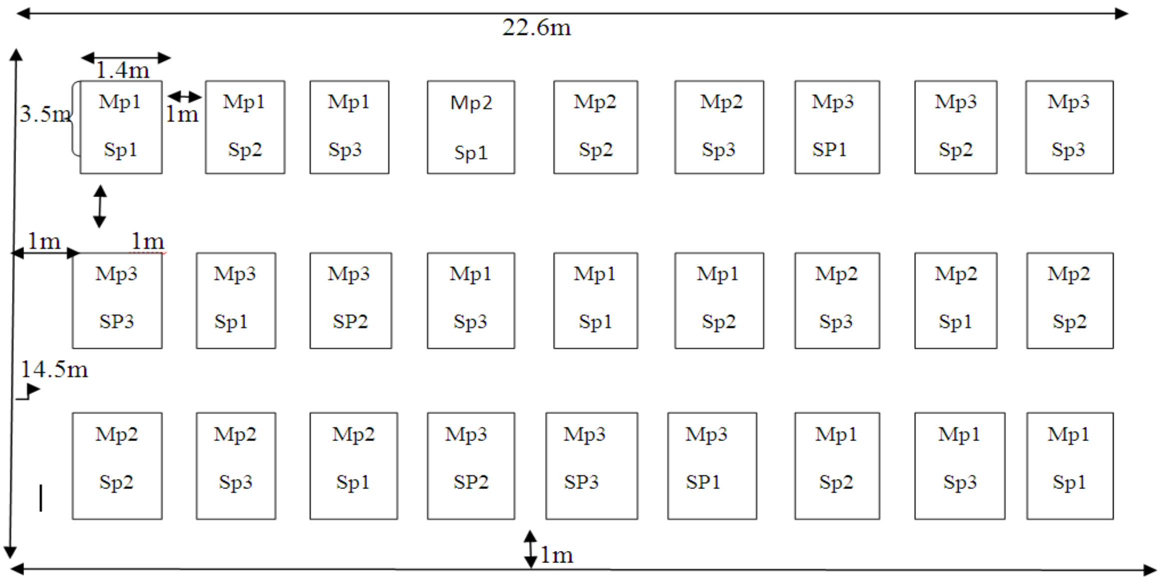

Figure 2: Layout of the experiment.

Note: - Mp1=Broad bed, Mp2= Tied ridging, Mp3= No tillage, Sp1= zero level manure, Sp2= 3 tons of manure and Sp3= 6 tons of manure.

2.3. Input Application and Crop Water Requirement

2.3.1 Farm yard manure

Different levels of air dried animal manure was broadcasted one month before bed preparation and planting to each respective plot to facilitate decomposition and incorporated in to the soil. Broadcast application of manure was strictly followed because local concentration of manure has a risk of burning of the crops and unnecessary wastage.

2.3.2 Inorganic fertilizer

According to Ethiopian Institute of Agricultural Research (EIAR, 2004) 100 kg DAP /ha, and 150 kg urea /ha is recommended for onion production. In addition to animal manure, the recommended inorganic fertilizer (150 kg urea /ha, 0.075kg/plot and 100 kg DAP /ha, 0.05 kg /plot) was added to fulfill the crop nutrient requirement.

2.3.3 Crop water requirement

Daily reference crop evapotraspiration (ETo) for each month of climatic record was calculated based on the modified FAO Penman Mentieth equation (FAO, 2009) using FAO CROPWAT software version 8.0. The input data include location (altitude, latitude and longitude of the meteorological station), monthly average daily value of maximum and minimum air temprature (^oC), air relative humdity, sunshine hours and wind speed. Crop water requirement (ETc) was determined for onion crop of the study area over the growing season based on the established procedure given by FAO (2009). Three water flow ditches were constructed, two at the border and one at the middle of the experimental site to collect and provide the irrigation water from the main channel to the plots. The location of these ditches were kept at 30 cm above the ground for the ease of water flow through siphon. Therefore, each plot was provided with constant supply of calculated irrigation water through furrow irrigation by using (4cm diameter) 12.56 cm^2 area size plastic siphons for discharge of estimated amount of water depending on CROPWAT program. Nine plastic siphons were used and each can discharge 20 liter /minute (checked by manually). As per the output of the model, the optimum seasonal irrigation requirement was found to be 585.44 mm. Since the experimental site has arid and semi arid environmental situation there was continuous follow up in CROPWAT irrigation scheduling. Onion require frequent light irrigation when 25 and 35% of available water in the first 0.3m soil depth is depleted for bulb and seed production respectively (Levy *et al*., 1981).

2.4 Data Collection

2.4.1 Soil sampling and measurements of soil parameters

Using an auger, disturbed composite surface soil samples (0-20cm) were collected from the experimental field for determination of soil physiochemical properties just before any input application and planting the crop and after harvesting. Root zone depth of onion is expected to be 40-46cm, but most water and nutrient uptake occurs from the top 30cm of soil (Janes, 1995). Moreover, disturbed soil samples were collected up to (0-60cm) depth at an interval of 20 cm with the help of hand auger from each plot with an interval of 15 days from the date of planting for moisture determination throughout the cropping period. In addition, undisturbed soil samples were also collected using core sampler from each plot for the determinations of bulk density, field capacity, permanent wilting point and available soil moisture of the soil.

2.4.2. Infiltration rate of soil

For the infiltration rate determination, the procedure for installing the double ring infiltrometer was used by selecting possible sites properly to prevent unusual surface disturbance, by animal burrows, stones that might damage the cylinder, etc. The measurement was done at two randomly placed infiltrometer within experimental site (FAO, 1989).

2.4.3. Soil analysis

Particle size distribution was determined by bouyoucos hydrometer method using sodium hexa metaphosphate as dispersing agent (Day, and Staney 1992). Soil pH was measured electrometrically by means of pH meter in a suspension of 1:2.5 soils to water ratio as described by Jackson (1958). Organic carbon was determined following the wet digestion method as described by Walkley and Black (1934) while total nitrogen was determined using the macro- Kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus was determined using spectrophotometer from extracts following the Olsen extraction method (Olsen *et al*., 1954). And available potassium was determined using ammonium acetate/acetic acid solution method. Exchangeable K^+ and Na were extracted with 1M ammonium acetate at pH 7.0. Exchangeable Ca and Mg were also measured from the extract with atomic absorption spectrophotometry while cation exchange capacity (CEC) of the soil was determined from ammonium acetate saturated samples that was subsequently replaced by Na from a percolated sodium chloride solution. The excess salts were removed by washing with alcohol and the ammonium that was replaced by sodium was measured using the Kjeldahl method as described by Bremner and Mulvaney, 1982 and reported as CEC.

Bulk density

Soil bulk density (ρb) was determined from undisturbed soil sample which is the ratio of the oven dry mass of soil and the bulk volume (Baruah and Barthakur, 1997).

$$\rho b = \frac{\text{dry soil weight}}{\text{volume of core ring}}$$

Particle density

Particle density was determined by collecting disturbed soil sample and passed through 2mm sieve. It was estimated by determining the mass and volume of soil solids. The mass of soil solid was determined by weighing the oven dry soil with required amount and the volume of the soil solid was determined by using replacement method. The weighed soil was poured into the water and the air bubbles were eliminated by stirring with a rod. The change in volume of water in the cylinder was taken as volume of soil particles then finally the soil particle density was calculated by the expression.

$$\rho s = \frac{dry\ soil\ weight}{volume\ of\ soil\ particle}$$

Porosity

Total porosity (*n*) of the soil sample was estimated on the basis of measured dry bulk density (ρb and particle density (ρs) as.

$$n = \left(1 - \frac{\rho b}{\rho s}\right) * 100$$

Soil moisture content (SMC) determination

The wet soil samples were weighed and placed in an oven at 105°C till constant weight attainment and then the weight of dry samples were measured.

$$SMC = \frac{Ww - Wd}{Wd} * 100$$

Ww = Weight of the wet soil (g)   Wd = Weight of the dry soil (g)

The volumetric soil moisture content, θ (%) was determined by considering the density of the soil water as 1 g/cm³ (ρw).

$$\theta = W * \rho b / \rho W$$

where: W = soil moisture content on mass base (%) ρ_b = bulk density (g/cm³) of the soil

Field capacity and permanent wilting point were determined at -0.33 and -15 bar pressure respectively using standard laboratory procedures on undisturbed soil samples. The suction range between 1 to 4.2 pF was determined with pressure plate apparatus (Baruah and Barthakur, 1997). In 1935, Schofield proposed the equation (Eq. 3.6) to express the energy or tension with which the water was retained to the soil which was important to develop soil moisture characteristics curve.

$$pF = Log_{10}[H]$$

where: - H= height of water column (m)

2.5. Collection of Agronomic and Meteorological Data

Agronomic observations were recorded during the course of experiment that include days to 70% maturity, plant height, plant stand count, total bulb yield, biomass, marketable yield and unmarketable yield. Daily rainfall amount, daily maximum and minimum temperature, wind velocity, relative humidity and solar radiation starting from one month prior to the date of sowing of the crop to the harvesting were collected from weather station installed at Gode town during the cropping season. Detail procedures of agronomic data collection are stated as follows.

Days to 70% maturity (days): The total numbers of days were counted from the date of transplanting until 70 percent of the plants have attained physiological maturity.

Plant height (cm): measured from the ground level to the top of a matured plant in each growth stage (initial stage, development stage, mid-stage and late stage).

Fresh shoot and bulb weight (g): fresh weight of biomass the above ground portion and bulbs of the sample plants.

Bulb dry weight (g): Weight of bulbs of the sample plants, after removing the shoot above the neck, the roots and soil, was taken after oven dry at 70 °C to a constant weight.

Shoot dry weight (g): Biomass of the above ground portion of the sample plants was taken by cutting the shoot above the neck at harvest and oven dried at 70 °C to a constant weight.

Dry total biomass (g): This was determined by summing up the shoot and bulb dry weights of sample plants.

Marketable bulb yield (t ha^{-1}): This was recorded as the weight of healthy and marketable bulbs that is greater than 60 g in size categories.

U**nmarketable bulb yield (t ha^{-1})**: unmarketable bulb yield is the yield of onion, which is not marketable (under sized, diseased and insect attacked bulbs). It was determined from bulbs harvested from plants in the middle of the experimental plot using digital sensitive balance.

Total bulb yield (t ha^{-1}): marketable bulb yield and unmarketable bulb yield were summed and expressed in tons ha^{-1}.

2.6. Data Analysis

Data were subjected to analysis of variance following a procedure appropriate to the design of the experiment (Gomez, 1984) using Gen Stat edition 13rd. The treatment means that were different at 5% levels of significance were separated using Duncan's Multiple Range Test

(DMRT). The degrees of relation and association between variables were also expressed by correlation coefficient.

3. RESULTS AND DISCUSSIONS

3.1 Rainfall Amount and Distribution during the Cropping Season

Rain pattern of study area is characterized by two rainy seasons and two dry seasons. The main rainy season extends from October to December and April to June and short rainy season stretches from July to September and January to March. Long year experience of average monthly rainfall distribution in study area can be located by Figure 4 below.

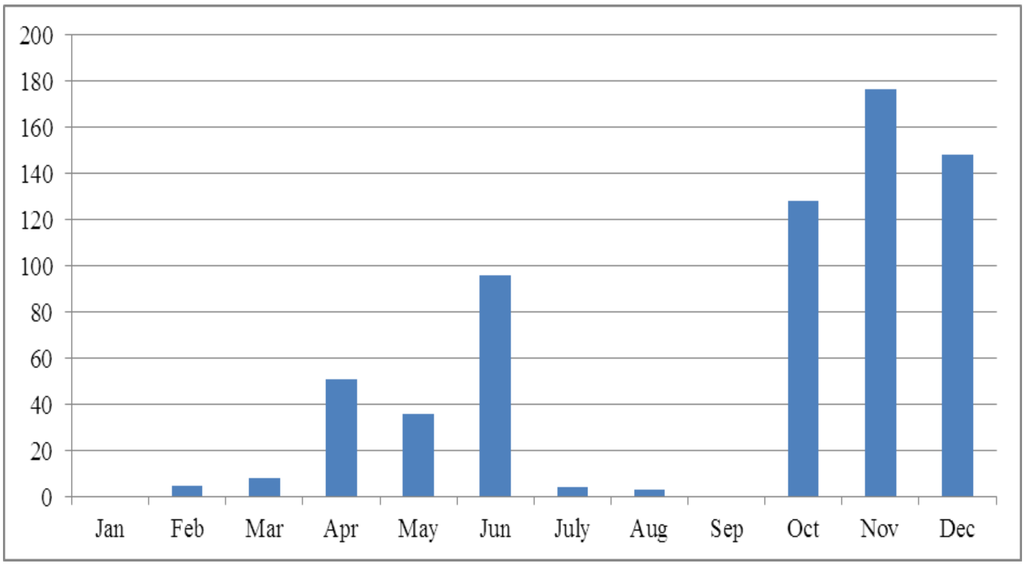

Figure 3: Average monthly rainfall (mm) of study area from 2005-2013.

Before planting

Table 1: Soil physiochemical properties of experimental site before planting.

Soil properties	value
Sand (%)	68.12
Silt (%)	9.14
Clay (%)	21.98
Textural class	Sandy clay loam
Bulk density (gm /cm^3)	1.20
Particle density (gm /cm^3)	2.72
Porosity (%)	56
PH (1.25 H_2O)	7.73
Total nitrogen (%)	0.10
Organic matter (%)	0.84
Exchangeable K (cmol(+)/kg)	0.49
Exchangeable Mg (cmol(+)/kg)	3.37
Exchangeable Ca (cmol(+)/kg)	9.63
Exchangeable Na (cmol(+)/kg)	0.76
Available Phosphorus (ppm)	8.60
Cation exchangeable capacity (meq/100g soil)	18.10

After harvesting

As indicated in Table 2, there is no significant difference (p≤0.05) in chemical properties of the soil due to tillage treatment. But manure application in general increased the residual amount of essential nutrients of the soil as compared to the control treatment and the difference was significant (p≤0.05). Application of 6 and 3 tons of manure per hectare increased the residual amount of the organic matter by (3.78%, 2.62%), phosphors (6.38%, 3.38%), Ca (13.48%, 10.64%), C.E.C (6.87%, 5.19%) and total nitrogen (10.28%, 7.11%) respectively in the soil as compared to the plots not treated with manure.

However, there was depletion of potassium (20.26%, 19.01%) in the soil by the applications of 6 ton and 3 ton manure per hectare and there is almost no significant change in magnesium and sodium. There was also reduction of available phosphorus in the control plot as compared to the soil before planting this may be due to high utilization of organic manure by the crop. The similar work was reported by Zerihun Girma (2011) in Somali region, and indicated that the application of 10 tons of manure /ha, has a significant effect on different soil chemical properties and organic matter content.

Table 2: Selected soil chemical properties of the surface soil of the experimental plots after harvesting.

Treatments	T.N %	O.M %	Ex. K Cmol (+)kg^{-1}	Ex. Mg Cmol (+) kg^{-1}	ex .Ca Cmol (+)kg^{-1}	ex .Na Cmol (+) kg^{-1}	av .P PPM	C.E.C Meq/100gm soil
Tied ridging	0.12	1.33	0.339	3.623	12.681	0.781	8.644	20.697
Zero tillage	0.12	1.27	0.347	3.616	12.693	0.765	8.614	20.710
Broad bed	0.12	1.26	0.351	3.610	12.691	0.767	8.654	20.700
0 tons man.	0.10^{a}	1.39^{a}	0.481^{a}	3.569^{a}	9.628^{a}	0.760	7.794^{a}	18.204^{a}
3 tons man.	0.13^{b}	1.46^{b}	0.284^{b}	3.724^{b}	13.677^{c}	0.757	8.670^{b}	21.430^{b}
6 tons man.	0.14^{b}	1.51^{c}	0.271^{b}	3.757^{b}	14.759^{b}	0.796	9.448^{c}	22.473^{b}

Note: Treatment means within a column followed by the same letter are not significantly different at P ≤ 0.05.

3.2. Soil Bulk density and Porosity after Harvesting

The analysis of the soil data on bulk density and porosity (Table 3) was highly significant (P < 0.01). Differences were visible in different levels of animal manure as compared to the plot which was not treated. This may be due to the effect of manure on soil aggregates formation and soil pore space increment. But there were no significant change in bulk density and porosity in different land management practices (tillage). The same result was reported by Sultani *et al.* (2007).

Table 3: soil bulk density and porosity.

Treatment	Bulk density(gm/cm^3)		Porosity (%)	
	Mean ± SE	CV %	Mean ±SE	CV%
Tiedridging (T2)	1.14 ± 0.086	2.27	57.96 ± 0.31	1.62
Zero tillage (T3)	1.17 ± 0.058	1.50	57.00 ± 0.21	1.15
Broad bed (T1)	1.15 ± 0.074	1.94	57.76± 0.27	1.40
0 tons manure (t1)	1.16[a] ± 0.044	1.12	56.71[a]± 0.16	0.85
3 tons manure (t2)	1.05[b] ± 0.038	1.00	58.44[b]±0.14	0.73
6 tons manure (t3)	1.03[c] ± 0.064	1.71	59.50[c]± 0.23	1.18
T1t1	1.15 [a]± 0.03	2.32	57.77[a]±0.01	1.15
T1t2	1.13[a] ± 0.02	1.78	57.81[a]±0.23	2.22
T1t3	1.12[a] ± 0.09	1.09	58.02[b]±0.09	0.99
T2t1	1.13[a] ± 0.01	2.21	57.91[a]±0.08	2.36
T2t2	1.06[b] ± 1.10	3.31	58.55[b]±0.13	1.19
T2t3	1.01[c] ± 0.04	1.13	59.66[c]±0.07	2.28
T3t1	1.16[a] ± 0.07	2.34	57.02[a]±0.02	2.38
T3t2	1.14[a] ± 1.11	4.23	57.82[a]±0.12	1.17
T3t3	1.13[a] ± 0.09	2.29	58.24[b]±0.03	2.15

Note: Treatment means within a column followed by the same letter are not significantly different at $P \leq 0.01$.

Table 4 Field capacity, PWP and AWC analysis.

Treatment	Field capacity %						Permanent welting point %						Available moisture content %					
	0-20		20-40		40-60		0-20		20-40		40-60		0-20		20-40		40-60	
	Mean± SE	CV %	Mean± SE	CV %	Mean± SE	CV %	Mean± SE	CV%	Mean± SE	CV %	Mean± SE	CV %	Mean± SE	CV%	Mean± SE	CV %	Mean± SE	CV%
T.ridge(T2)	32.76±0.48	4.43	31.83±0.48	4.53	31.57±0.49	4.80	19.62±0.18	2.83	18.91±0.35	5.63	18.72±0.41	6.56	13.06±0.38	8.78	12.85±0.22	5.17	12.62±0.32	7.7
Z.tillag(T3)	32.14±0.55	5.17	30.87±0.51	5.05	30.30±0.57	5.64	19.03±0.13	2.13	18.29±0.19	3.14	18.06±0.21	3.48	13.18±0.45	10.34	12.58±0.36	8.71	12.36±0.34	8.3
B bed (T1)	32.52±0.43	3.98	31.45±0.19	1.85	30.33±0.16	1.60	19.64±0.16	2.47	18.64±0.23	3.79	17.83±0.16	2.85	12.88±0.27	6.48	12.81±0.18	4.40	12.41±0.20	5.2
0 tons (t1)	29.6^{c}±0.15	1.51	31.1^{a}±0.38	3.85	29.1^{c}±0.27	2.79	18.8^{a}±0.03	1.57	17.7^{a}±0.10	1.82	17.2^{a}±0.12	2.13	11.7^{a}±0.14	3.60	12.3^{a}±0.32	7.99	12.1^{a}±0.36	8.8
3 tons(t2)	32.8^{b}±0.06	1.55	31.5^{a}±0.23	2.28	30.8^{a}±0.29	2.82	18.6^{a}±0.17	2.62	18.7^{a}±0.18	2.87	18.6^{a}±0.28	4.62	13.2^{c}±0.11	2.65	12.7^{c}±0.13	4.16	12.1^{a}±0.24	6.1
6 tons (t3)	36.6^{a}±0.11	1.97	32.5^{a}±0.16	2.50	31.7^{b}±0.21	2.06	19.7^{b}±0.14	2.14	19.3^{b}±0.19	3.03	18.7^{a}±0.18	2.92	16.9^{b}±0.15	3.19	14.2^{a}±0.21	4.90	13.0^{b}±0.13	3.2
T1t1	32.5^{b}±0.12	1.67	31.4^{a}±0.21	2.30	31.6^{a}±0.22	2.11	18.9^{a}±0.16	3.21	17.6^{a}±0.11	3.21	17.3^{a}±0.22	2.21	13.6^{c}±0.12	2.13	13.8^{c}±0.41	4.31	14.3^{b}±0.14	2.2
T1t2	33.1^{b}±0.14	2.01	33.2^{b}±0.19	2.22	32.4^{b}±0.33	1.91	19.5^{b}±0.21	2.08	18.8^{a}±0.14	2.18	18.4^{a}±0.11	1.17	13.5^{c}±0.21	2.07	14.8^{b}±0.33	4.08	14.0^{b}±0.12	3.1
T1t3	33.4^{b}±0.21	1.19	33.3^{b}±0.20	1.19	32.5^{b}±0.15	2.12	19.9^{b}±0.32	2.11	19.1^{b}±0.22	1.18	19.2^{b}±0.22	2.11	13.4^{c}±0.31	1.19	14.2^{b}±0.14	3.09	13.3^{b}±0.21	2.2
T2t1	33.7^{b}±0.15	1.32	32.5^{b}±0.11	2.11	31.4^{a}±0.31	1.18	18.5^{a}±0.22	2.13	17.9^{a}±0.31	2.11	18.5^{a}±0.31	2.31	15.2^{b}±0.22	2.21	14.6^{b}±0.23	2.78	12.9^{a}±0.23	2.1
T2t2	34.1^{a}±0.19	1.42	33.7^{b}±0.33	2.33	32.5^{b}±0.22	3.01	19.7^{b}±0.11	2.22	18.7^{a}±0.21	2.27	19.2^{b}±0.22	2.07	14.4^{b}±0.33	2.01	15.0^{b}±0.22	2.33	13.3^{a}±0.25	1.1
T2t3	36.7^{a}±0.18	2.20	34.6^{b}±0.22	1.19	33.7^{b}±0.33	2.32	19.8^{b}±0.33	3.10	18.9^{a}±0.33	2.19	19.7^{b}±0.11	2.32	16.9^{b}±0.11	1.21	15.7^{b}±0.33	2.19	14.0^{b}±0.22	2.1
T3t1	32.2^{b}±0.21	1.17	31..4^{a}±0.11	2.18	30.3^{a}±0.22	2.09	18.5^{a}±0.25	2.34	17.8^{a}±0.25	2.21	17.8^{a}±0.44	2.11	13.7^{c}±0.33	2.13	13.6^{c}±0.44	3.01	12.5^{a}±0.44	2.1
T3t2	32.5^{b}±0.11	1.12	31.9^{a}±0.21	3.06	30.5^{a}±0.44	2.02	19.2^{b}±0.22	2.17	18.7^{a}±0.33	1.18	18.7^{a}±0.25	3.01	13.3^{c}±0.31	3.21	13.2^{c}±0.31	2.29	11.8^{a}±0.32	1.2
T3t3	32.7^{b}±0.22	1.32	31.5^{a}±0.13	2.29	30.4^{a}±0.23	1.19	19.8^{b}±0.34	2.16	18.7^{a}±0.45	2.17	18.5^{a}±0.32	2.19	12.9^{a}±0.41	2.29	12.8^{a} ± 0.11	2.15	11.9^{a}±0.23	2.2

Note: Treatment means within a column followed by the same letter are not significantly different at $P \leq 0.05$.

3.3. Infiltration Rate

The basic infiltration rate of the soils of the study area was observed as 17.61 mm/hr. This value was less than 30 mm/hr (Figure 4) which is in an expected range for sandy soil. The infiltration data was used as an input data for CROPWAT model.

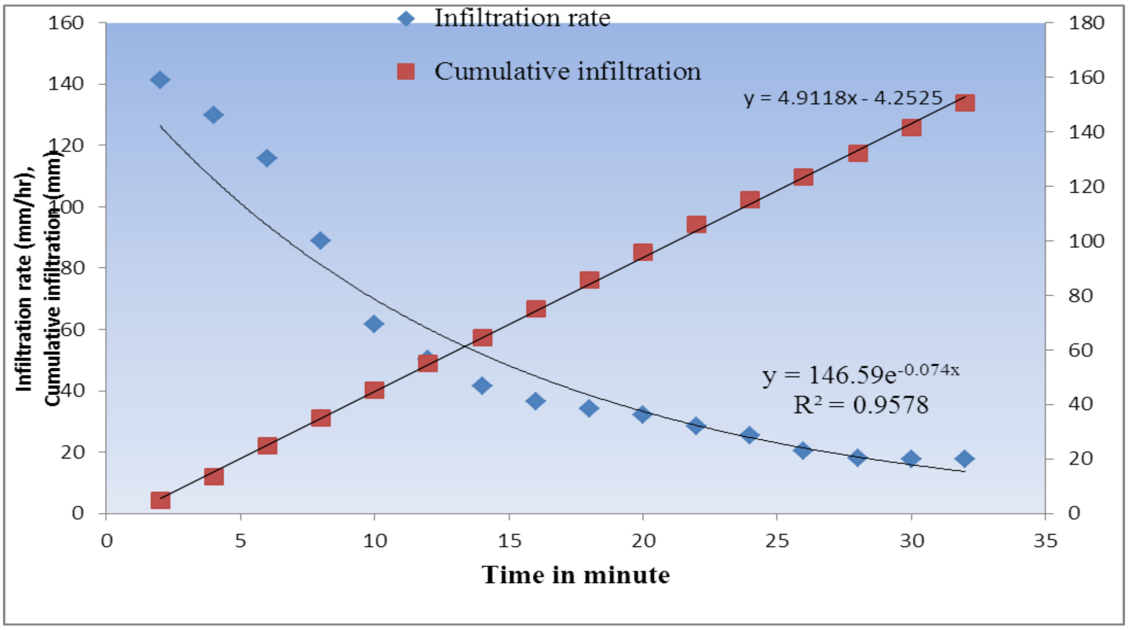

Figure 4: Infiltration characteristics of the soil of experimental site.

3.4. Crop Water Requirement of Onion

The seasonal irrigation water requirement was estimated to be 585.44 mm. The net irrigation water requirement and gross irigation water requirement were 583.04 mm and 828.34 mm respectively (Table 5). During the dry season, onion is cultivated under total irrigation mostly by surface (wild flooding, furrow and check basin) irrigation method. Seasonal water applied to the crop by farmers range from 400 to 700 mm depending on water availability and frequency of irrigation (NAERLS, 2009). Experience, from study area, the farmers irrigation intervals range from 3 to 7 days depending on soil type and access to water.

Table 5: Crop water requirement of onion during the growing season.

Month	CWR (mm)	Rain (mm)	Pe (mm)	NIWR (mm)	GIWR (mm)
Jan	116.4	0	0	116.40	158.35
Feb	182.22	0	0	182.22	260.28
Mar	167.78	2.0	1.6	166.18	239.67
App	119.04	1.1	0.8	118.24	170.04
Total (120)	585.44	3.1	2.4	583.04	828.34

Where CWR = crop water requirement, Pe = effective rainfall, NIWR = net irrigation water requirement and GIWR = gross irrigation water requirement.

3.5. Soil Moisture Content at Different Sampling Period

Table 6 volumetric moisture content (%) with respect to metric potential in the soil profile.

Soil depth cm	Metric potential cm						
	-32	-100	-200	-333	-5012	- 150000	AWC %
0-20	44.22	43.15	42.01	41.22	36.51	27.56	13.66
20-40	43.19	42.11	40.52	38.43	31.04	27.02	11.41
40-60	41.21	40.02	39.17	35.11	30.01	26.89	8.22

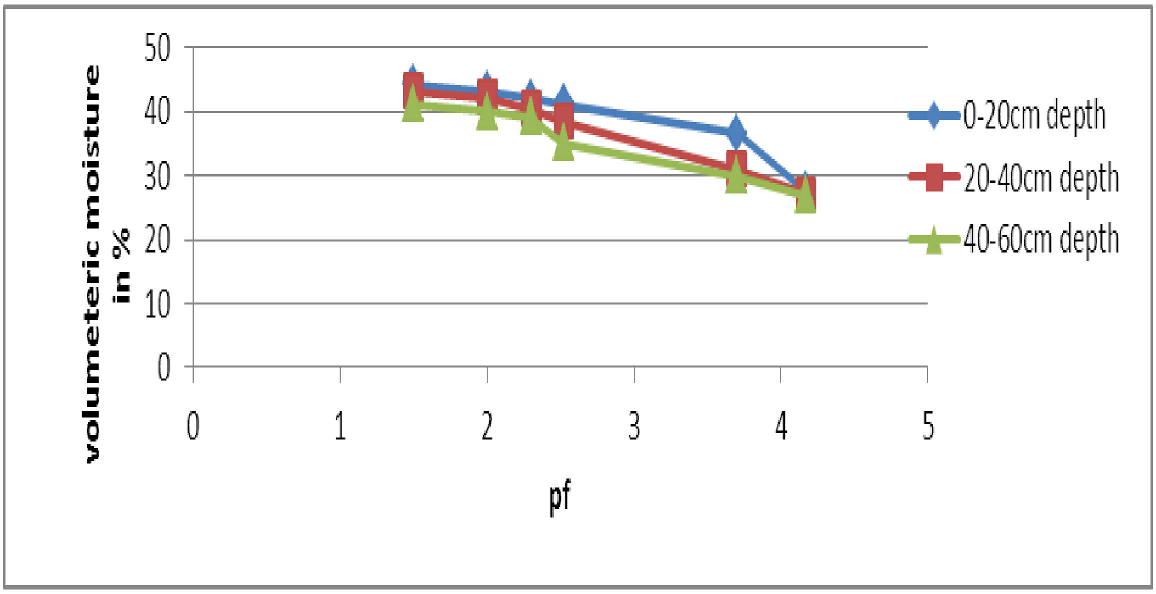

Figure 5: Soil moisture content characteristic curve.

3.6. Average soil moisture content of cropping season

Table 7 indicates that there was a significant (P<0.01) soil moisture difference in T3t1 with T3t3, T2t1, T2t2, T2t3, T1t2 and T1t3 but no difference in compared to T3t2 and T1t1. The moisture content had also a significant difference due to tied ridging with 3 tons of animal manure over broad bed and zero tillage with zero, 3 and 6 tons of manure and tied ridging without manure at the specified depth. Broad bed with 6 tons of manure shows adequate moisture increment as compared to the rest except tied ridge with 3 and 6 tons of manure. However there was no any significant (P > 0.0) difference observed between zero tillage with 6 tons of manure and tied ridging without manure and broad bed with 3 tons manure.

Table 7: Average gravimetric soil moisture content over the total growing period of the crop at the total depth of 0-60 cm.

Treatments	Mean ± SE	CV%
Zero tillage x control (T3t1)	31.01[a]±0.09	2.5
Zero tillage x 3tons (T3t2)	31.80[a]±0.19	1.45
Zero tillage x 6tons (T3t3)	32.46[b]±0.21	2.05
Tied ridge x control (T2t1)	32.28[b]±0.17	2.15
Tied ridge x 3tons (T2t2)	34.98[c]±0.07	2.14
Tied ridge x 6tons (T2t3)	35.67[d]±0.18	2.45
Broad bed x control (T1t1)	31.10[a]±0.06	2.19
Broad bed x 3 tons (T1t2)	32.42[b]±0.08	2.09
Broad bed x 6 tons (T1t3)	33.58[e]±0.12	1.97

Note: Treatment means within a column followed by the same letter are not significantly different at p≤0.01.

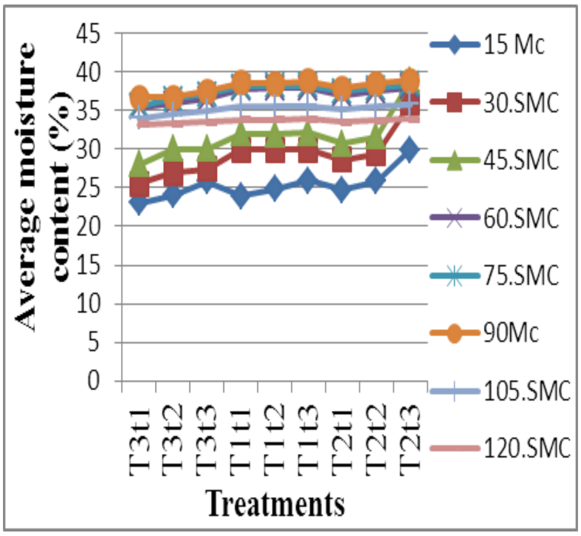

Figure 6 Average moisture content (Mc %) at 0-60 cm soil depth on different sampling period.

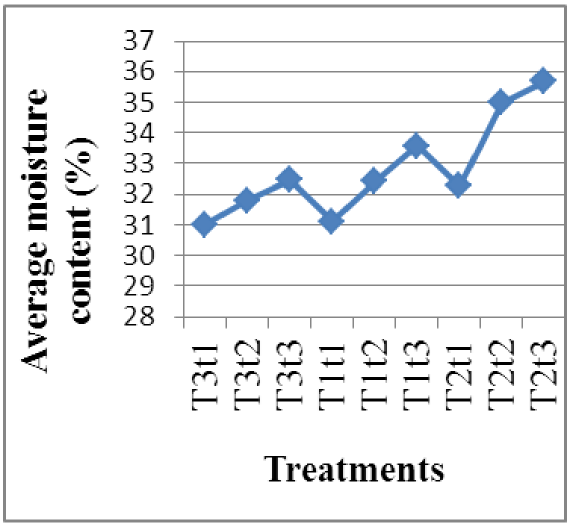

Figure 7 Average moisture (Mc %) content of the treatments over total growing time

3.7 Characterization of Treatment with Plant Parameters

3.7.1 Days to 70% maturity

Table 8 indicates that there was significant effect ($P \leq 0.01$) on days to 70 % maturity of the crop due to the moisture conservation structures and the application of manure. It further indicates that the maturities of the crop were significantly ($P \leq 0.01$) delayed due to tied ridging with highest dose of manure (6 tons /ha) as compared to broad bed and zero tillage and the plots which were not treated with manure.

3.7.2 Plant height

Table 8 also revealed that plant height at different growth stages (initial, mid, development and late stage). There was a significant height ($P \leq 0.01$) difference in tied ridging with 6 tons of manure compared to all treatments and the highest plant height also recorded here in all stages of the crop. But there was no significant height difference in application of 3 tons of manure with remaining all treatments except tied ridging with 6 tons of manure.

Table 8: Treatment effects on plant maturity and plant height at different growth stages.

Treatment	70% maturity		PHI		PHII		PHIII		PHIV	
	Mean ±SE	CV	Mean ±SE	CV	Mean ±SE	CV	Mean ±SE	CV	Mean ±SE	CV
T1t1	110.6^{a}±0.33	1.52	36.2^{a}±0.64	11.02	46.8^{e}±0.11	1.04	57.0^{f}±0.01	1.04	56.0^{h}±0.03	1.1
T1t2	111.1^{a}±0.33	1.57	36.1^{a}±0.02	1.04	47.0^{b}±0.12	1.06	57.2^{f} ±0.14	1.04	57.0^{f}±0.02	1.06
T1t3	115.3^{b}±0.31	1.5	37.1^{b}±0.05	1.02	47.1^{b}±0.05	1.02	58.0^{b}±0.63	1.09	58.5^{b}±0.03	1.01
T2t1	110.5^{a}±0.33	1.52	37.0^{b}±0.23	1.10	47.3^{b}±0.01	1.04	58.6^{b}±0.08	1.26	58.0^{b}±0.14	1.04
T2t2	111.3^{a}±0.33	1.51	37.1^{b}±0.01	1.05	48.1^{c}±0.01	1.05	58.7^{b}±0.03	1.10	58.6^{b}±0.08	1.23
T2t3	117.3^{d}±0.13	1.49	38.0^{c}±0.02	1.10	49.0^{d}±0.08	1.03	60.1^{c}±0.02	1.06	60.0^{c}±0.21	1.06
T3t1	111.0^{a}±0.57	1.9	36.0^{a}±0.01	1.08	47.0^{b}±0.01	1.08	57.2^{f}±0.02	1.08	57.0^{f}±0.04	1.13
T3t2	112.6^{c}±0.33	1.51	36.4^{a}±0.01	1.04	47.2^{b}±0.01	1.08	57.9^{f}±0.01	1.04	57.1^{f}±0.03	1.09
T3t3	116.3^{b}±0.31	1.49	37.1^{b}±0.17	1.08	48.1^{c}±0.01	1.04	59.7^{c}±0.02	1.07	59.2^{c}±0.03	1.08

Note: Treatment means within a column followed by the same letter are not significantly different at $p \leq 0.01$

PHI=plant height at initial stage, PHII=plant height at mid-stage, PHIII= plant height at development stage, PHIV=plant height at late stage.

3.7.3 Shoot dry weight

When the rate of farmyard manure was increased from 0 to 6 t ha^{-1}, shoot dry matter yield did have change significantly ($P < 0.05$). There was a significant change in shoot dry weight on tied ridging with 6 tons of manure compared to the rest but, no shoot dry weight difference on broad bed with 3 tons and zero tillage with 0 ton, broad bed with 6 tons and zero tillage with 3 tons, zero tillage with 6 tons and tied ridge with 3 tons. The highest shoot dry weight (24.2 gm /plant) was recorded on tied ridging with 6 tons manure (T2t3) whereas the lowest (16.0 gm /plant) was observed on broad bed with 0 tons manure (T1t1) (Table 9).

Table 9: Interaction effect of treatments on different crop parameters.

Treat ment	Shoot fresh wt gm /plant		Shoot dry wt gm /plant		Dry bulb wt gm /plant		fresh bulb wt gm /plant		Dry biomass gm /plant	
	Mean±SE	CV %	Mean±SE	CV %	Mean±SE	CV %	Mean±SE	CV %	Mean±SE	CV %
T1t1	141.0^{a}±0.01	1.01	16.0^{a}±0.05	1.05	60.0^{a}±0.08	1.02	121.06^{a}±0.02	1.03	76.0^{a}±0.01	1.02
T1t2	141.9^{a}±0.03	1.04	17.0^{b}±0.04	1.43	60.2^{a}±0.02	1.08	122.70^{b}±0.08	1.01	77.3^{b}±0.04	1.05
T1t3	142.5^{b}±0.03	1.03	18.7^{c}±0.02	1.20	61.5^{b}±0.01	0.04	125.5^{c}±0.02	1.03	79.6^{c}±0.03	1.06
T2t1	142.1^{b}±0.08	1.01	20.4^{d}±0.02	1.25	61.7^{b}±0.02	1.07	130.0^{d}±0.57	1.76	81.7^{d}±0.01	1.01
T2t2	143.1^{c}±0.03	1.03	21.9^{e}±0.01	1.11	62.5^{c}±0.02	1.07	132.0^{e}±.56	1.75	83.7^{e}±0.04	1.08
T2t3	145.1^{d}±0.01	1.01	24.2^{f}±0.08	1.06	66.2^{d}±0.05	1.01	136.6^{f}±0.30	1.38	90.0^{f}±0.01	1.01
T3t1	141.0^{a}±0.08	1.01	17.0^{b}±0.08	1.08	60.2^{a}±0.01	1.03	122.9^{b}±0.52	1.79	77.2^{b}±0.08	1.17
T3t2	141.9^{a}±0.03	1.04	18.2^{c}±0.01	1.11	61.1^{b}±0.08	1.02	124.6^{g}±0.32	1.45	79.3^{c}±0.02	1.04
T3t3	143.2^{c}±0.02	1.02	20.1^{e}±0.08	1.07	62.2^{c}±0.08	1.02	126.1^{h}±0.17	1.23	82.4^{g}±0.01	1.02

Note: Treatment means within a column followed by the same letter are not significantly different at $p \leq 0.05$

3.7.4 Shoot fresh weight

Table 9 indicates the interaction effect of land preparation (tied riding, broad bed and zero tillage) methods with different levels of animal manure on vegetative growth of the crop. The analysis of variance showed that the main effects of tillage, and farmyard manure had highly significant ($P < 0.05$) effects on shoot fresh weight of onion. Shoot fresh weigh increased when the rates of manure was high in tied ridging. Thus, significantly highest shoot fresh weight was obtained in response to the application of 6 tons /ha manure in tied ridging plot 145.1 gm /plant followed by zero tillage with 6 tons /ha manure application (143.2 gm /plant). Shoot fresh weight was increased in response to tied ridging and farmyard manure application probably due to the increase in further vegetative growth on the crop. The increase in shoot fresh weight yield of the onion plants may also be attributed to the role of manure not only supply of nutrients but also organic carbon that can be a source of energy for soil biota that improve soil health and chemical characteristics of the soil. This result is also in agreement with that of Palm *et al* (1997) who reported that the beneficial effects of combined organic and mineral fertilizer application were attributable to the influence of the organic input on nutrient availability through addition of nutrients, mineralization-immobilization patterns, being an energy source for microbial activities, as well as on its effect of being a precursor to soil organic matter (SOM).

3.8 Yield Components and Yield

3.8.1 Dry bulb weight, fresh bulb weight and dry biomass

The analysis of variance revealed that the main effects of tillage practices and farmyard manure had highly significant ($P < 0.05$) effects on bulb dry weight. Application of 3 tons of manure had no significant ($P< 0.05$) change in dry bulb weight compared to the plot which was not treated with manure in broad bed and zero tillage system. However, 6 tons of manure had brought a visible change in all treatments except zero tillage with 6 tons /ha manure. Similarly, dry biomass and fresh bulb weight also had a significant difference in a plot treated with and without manure application along tied ridging with 6 tons of manure with zero tillage and broad bed with 3 tons of manure and without manure application (Table 9). The increased response of dry total biomass to increasing rates of farmyard manure could be attributed to enhanced shoot and bulb production due to increased photo assimilation and dry matter accumulation.

3.8.2 Stand count

The analysis of variance (Table 10) indicates that final stand count was not significantly influenced ($P \leq 0.05$) by the application of different tillage methods and different levels of animal manure. Even though the difference was not statically significant, but numerically there was stand count difference which may cause significant effect on other yield component.

Table 10: Stand count analysis.

Main plot Treatment (T1)	**Mean ±SE**	**CV%**
t1	237.33[a]±0.33	1.60
t2	238.33[a]±0.33	1.59
t3	237.33[a]±0.33	1.57
Main plot treatment (T2)		
t1	238.33[a]±1.20	1.75
t2	237.66[a]±0.33	1.20
t3	237..00[a]±0.57	1.36
Main plot treatment (T3)		
t1	239.00[a]±1.00	1.72
t2	239.00[a]±0.00	1.41
t3	238.00[a]±0.56	1.43

Note: Treatment means within a column followed by the same letter are not significantly different at $p\leq0.05$

3.8.3 Marketable fresh bulb yield

The analysis of variance indicates that the main effects of tillage method at (P < 0.01) and the main effect of FYM was significant (P < 0.01) on marketable fresh bulb yield (Table 11). The table also shows high manure was required to realize significant increases in fresh marketable bulb yield of onion on the experimental soil. Corroborating in these results, Randall *et al*. (1999) also reported that poultry manure at the rates of 2.47-4.94 t ha^{-1} either alone or in combination with synthetic fertilizer produced acceptable yields of marketable onions. Therefore, the highest (30.01 t /ha) marketable yield was recorded on tied ridging with 6 tons /ha manure whereas the lowest (25.51 t /ha) was observed on broad bed with no manure application.

3.8.4 Unmarketable yield

The interaction effect of tillage methods and farmyard manure applications were also significant (P < 0.01) on unmarketable yield. The result obtained from this experiment was also in accord with that of Syed *et al*. (2000) who reported that untreated plot and those treated with high level of manure produced maximum number of unmarketable bulbs and marketable yield respectively. The results are also in agreement with the findings of Al-Moshileh (2001) and Ghaffoor *et al*. (2003) who indicated that untreated plot with manure produced significantly maximum unmarketable bulb yields. This may be attributed to small-sized bulbs produced in the untreated plots due to nutrient deficiency. Then, the highest (4.02 t /ha) unmarketable bulb yield was recorded on broad bed with 0 ton /ha manure but the lowest (2.82 t /ha) was indicated on tied ridging with 6 tons /ha manure and total bulb yield was the sum of unmarketable and marketable yield, then the highest (32.92 t/ha) was recorded on tied ridging with 6 tons /ha manure application (Table 11)

Table 11: Interaction effect of tillage method and manure on yield components.

treatment	MY ton /ha		UNMY ton /ha		TY ton /ha	
	Mean± SE	CV%	Mean ±SE	CV%	Mean ±SE	CV%
Broad bed x control (T1t1)	25.51^{a}± 0.07	1.87	4.02^{a}±0.02	1.87	29.54^{a}±0.05	1.11
Broad bed x 3 (T1t2)	26.30^{a}±0.05	1.02	3.14^{b}±0.02	1.32	29.44^{a}±0.02	1.11
Broad bed x 6 (T1T3)	28.24^{b}±0.01	1.08	2.93^{c}±0.02	1.23	31.17^{b}±0.06	1.03
Tied ridge x control (T2t1)	26.96^{a}±0.02	1.18	3.70^{b}±0.08	1.42	30.66^{b}±0.02	1.13
Tied ridge x 3 (T2t2)	28.05^{b}±0.02	1.16	3.01^{b}±0.01	1.82	31.07^{b}±0.02	1.11
Tied ridge x 6 (T2t3)	30.10^{c}±0.01	1.08	2.82^{c}±0.02	1.27	32.92^{b}±0.02	1.13
Zerotillage x control (T3t1)	26.77^{a}±0.05	1.34	3.82^{b}±0.03	1.94	30.59^{b}±0.06	1.38
Zero tillage x 3 (T3t2)	27.41^{b}±0.01	1.09	3.15^{b}±0.01	1.31	30.57^{b}±0.03	1.18
Zero tillage x 6 (T3t3)	28.27^{b}±0.01	1.08	3.49^{b}±0.11	1.8	31.76^{b}±0.02	1.27

Note: Treatment means within a column followed by the same letter are not significantly different at p≤0.01

Hint: MY=marketable yield, UNMY=unmarketable yield, TY=total yield

3.9 Relationships among the Parameters

Correlation coefficient values (r) computed to display the relationships between vegetative growths; yield components and average soil moisture are shown in Table 12. The correlation values showed apparent association of the parameters of the crop with each other and indicate the magnitude and direction of the association and relationships.

Thus, there was positive and highly significant correlation between average moisture content to all parameters. Plant shoot fresh weight (0.97**), shoot dry weight (0.97**), dry biomass (0.86**) were all positively and highly significantly correlated with average moisture content in both main plot and sub plot effect, indicating that improvement in one of these parameters may also lead to improvement in shoot dry matter yield. Similarly marketable yield (0.96**) was highly correlated with total bulb yield in all treatments whereas shoot fresh weight and dry bulb weight were not significantly related.

The observed positive and significant correlation values between shoot dry weight and total bulb yield (r = 0.96**) as well as marketable bulb yield (r = 0.96**) indicates the presence of a close relationship among these parameters (Table 20). The association of total bulb yield could have resulted from higher shoot dry matter yield as a consequence of interception of more photosynthetically active radiation, efficient radiation use, more dry matter accumulation and partitioning to bulb (Marschner, 1995; Reddy and Reddi, 2002; Nasreen *et al*., 2007).

Moreover, average fresh bulb weight (r = 0.96**) was positive and highly significantly correlated with total bulb yield. Plant height (0.78*), maturity (0.76*) and dry biomass (0.74*) were significantly correlated with shoot fresh weight. However, total bulb yield, maturity, dry bulb weight and unmarketable bulb yield were negatively correlated even if the relation was not significant. Average soil moisture content (-0.66**) was highly negatively correlated with unmarketable bulb yield.

Table 12: Simple correlations of average soil moisture, vegetative and yield components of onion as influenced by tillage practice and applied animal manure.

	Sfw	Sdw	Fbw	Dbw	M	Db	Mb	Unb	Tb	Ph	Mc
Sfw	1	0.97**	0.67ns	0.88ns	0.96ns	0.86**	0.93ns	-0.98ns	0.75ns	0.88*	0.93**
Sdw	0.94**	1	0.89ns	0.93*	0.99ns	0.92*	0.97**	-0.96ns	0.83**	0.93*	0.91**
Fbw	0.87ns	0.96ns	1	0.96**	0.99ns	0.96*	0.99*	-0.91ns	0.89**	0.97ns	0.97**
Dbw	0.96ns	0.96ns	0.92**	1	0.98ns	0.98ns	0.99ns	-0.77ns	0.98*8	0.99ns	0.93*
M	0.96ns	0.96ns	0.96ns	0.98ns	1	0.96ns	0.99ns	-0.88ns	0.91ns	0.97*	0.76*
Db	0.75*	0.99**	0.43**	0.67**	0.62ns	1	0.98	-0.77*	0.94ns	0.96*	0.78**
Mb	0.91ns	0.96**	0.73**	0.87ns	0.86ns	0.87ns	1	-0.83*	0.94**	0.99ns	0.99**
Unb	-0.74ns	0.84ns	-0.42ns	0.58ns	-0.42ns	-0.57n	-0.82*	1	-0.61*	-0.76ns	-0.68ns
Tb	0.87**	0.93**	0.78**	0.91**	0.78ns	0.91**	0.96**	-0.64ns	1	0.97**	0.99**
ph	0.78*	0.70n*	-0.08ns	-0.04n	0.768*	0.74*	-0.15ns	-0.20ns	-0.10ns	1	0.97**
Mc	0.89**	0.85*	0.68**	0.71*	0.81**	0.94*	0.95**	-0.66*	0.91**	0.89**	1

*= significant at P< 0.05, ** = highly significant at P< 0.01, ns = non significant P<0.05

Correlation coefficient above the diagonal are for main plot effect and correlation coefficient below the diagonal are for sub plot effect.Sfw=shoot fresh weight, Sdw=shoot dry weight, Fbw=fresh bulb weight, Dbw=dry bulb weight, M=maturity, Db=dry biomas, Mb=marketable bulb yield, Unb=unmarketable bulb yield, Tb=tatol bulb yield, Ph=plant heght, Mc=average moisture content

4. SUMMARY, CONCLUSION AND RECOMMENDATION

4.1. SUMMARY AND CONCLUSION

Different land preparation (tillage methods) integrated with soil fertility management is an important approach to enhance crop production in dry land areas. In dry land areas, small amount of rainfall with erratic and uneven distribution pattern affect crop production. For this reason, there must be some sort of land preparation practices needed like soil moisture conservation techniques. Land preparation is defined as different moisture conservation tillage methods that increase the amount of water stored in the soil profile by trapping or holding the applied water.

4.2. Recommendation

Based on the findings obtained from this experiment, the following recommendations are forwarded.

❖ Since the study area has a problem of low, erratic and uneven rainfall distribution throughout the year, the farmers should be advised to use tied ridging with 6 tons /ha of animal manure as a better option at the moment. Tied ridging with 3 tons /ha and zero tillage and broad bed with 6 tons /ha animal manure are ranked next for the sake of the availability of manure and conserving soil moisture.

- The moisture conservation performance of tillage's (tied ridging, zero tillage and broad bed) can be improved by the application of manure resulting to high soil infiltration rate. So integrating these tillage methods with manure may be the important approach for dry land farmers.

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