Assessment of ~~G~~growth and yield ~~response~~ of watermelon and the soil physical properties ~~in relation~~ in response to different tillage methods ~~and soil physical properties~~.

Abstract: *Field experiment was conducted to investigate the response of soil physical properties, crop growth, yield and yield components of watermelon to different tillage methods in the transitional zone of Ghana in a two year period. The tillage treatments used in the study were plough and harrowed (PH), minimum tillage (MT) and no tillage (NT) laid out in a Randomised Complete Block design (RCBD) with 3 three replications. The two field experiments were undertaken at the experimental site (Nursery) of the University of Education, College of Agriculture, Mampong-Ashanti, located between latitude $07^0 – 08^0$N and Longitude $01^0 – 02^0$ W situated within the transitional agro-ecological zone that is between the forest and Guinea Savannah zones characterized with two rainfall regimes with annual rainfall of 1094.2mm with 30^0C temperature. The soil ~~-belonging to the Bediase series with ochrosol type formed from voltain sandstone~~ and a pH between 5.5 to 6.5. ~~belonging to the Bediase series with ochrosol type formed from voltain sandstone.~~ The statistical analysis revealed that, tillage methods significantly affected soil physical properties particularly, total porosity, volumetric water content and bulk density. Also, tillage methods influenced crop growth, (number of leaves and vine length), yield and yield components of watermelon in the order of Plough and harrowed > Minimum tillage > No-Tillage in almost all the treatments. Accordingly, the ploughed and harrowed (PH) was found to be more appropriate and profitable tillage method ~~in~~ to improving soil physical properties, crop growth, yield and yield components of watermelon in the forest-transitional of Ghana.*

Comment [R1]: Detail the coordinate geographic (e.g. $7^0$02'23"N and $1^0$22'10"W)

Key words: *Citrullus vulgaris*, ~~B~~bulk density, tillage, ~~moisture,~~ total porosity, volumetric water content, yield

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1. Introduction

Watermelon (*Citrullus vulgaris*) which belongs to the family cucurbitaceae is originated in tropical Africa and it is regarded as one of the important fruit vegetables in Ghana [1]. The crop does well relatively in most parts of the country and is regarded as one of the valuable crops for some tribes in Ghana apart from being used as fruits. The "Ga" tribe in Ghana for example, use it for their annual "Homowo" festival [2]. It requires relatively stable and relatively high temperature of about 25°C to 32°C but high humidity and precipitation leads to foliar diseases [1] thus why the crop does well in both northern and southern part of the country.

There has been an increase demand and use of watermelon in many Ghanaian homes due to its nutritional benefits. Most homes will normally squeeze the juice and use as drinks not to talk about the increasing demand by marketers and juice factories for drinks. Due to this demand, total production in Ghana needs to increase in order to meet the demand of the fruit in the country. Cultivation of watermelon with appropriate tillage method would therefore help increase production since most resource poor vegetable farmers do not resort to scientific methods of cultivation to maximize production to meet the current demand.

Soil tillage is one of the factors that affect the physical properties of soil and crop yield. According to Khurshid *et al*. [3], soil tillage contributes up to 20% of crop yield. Proper use of tillage normally improve soil related constraints but improper tillage most of the time causes a range of undesirable processes such as destruction of soil structure, depletion of organic matter,

accelerated erosion, disruption of water cycle and plant nutrient availability [4]. Bad tillage operations normally leads to destruction and causes harm to the soil. In view of this, there has been a paradigm shift to conservation to control erosion and other soil factors [5].

Dauda and Maina [6], observed that, watermelon plant length was affected by the tillage methods employed in planting. Steiner [7] reported that among the functions and reason why farmers invest labour and money in tillage was to increase water infiltration to enhance soil moisture storage and reduce run-off and to control insect pests in soil. Keshavarzpour and Rashidi [8] observed that tillage methods significantly affected crop yield, fruit weight, vine length and fruit length of water-melon.

Conventional tillage method has been found to modify the soil physical properties particularly, bulk density, penetration resistance and moisture content. Again, this method loosens and improves percolation while conservation and no-tillage leaves the soil intact [9] because the soil is not disturbed. Khan *et al.* [10] observed that conventional tillage method produces a favourable environment for crop growth and nutrient use. Again, Rashidi and Keshavarzpour [11] reported that annual disturbance and pulverizing caused by conventional tillage method produce a finer and loose soil structure which in turn affect the seedling emergence, plant population density and consequently crop yield.

In another breadth, conservation tillage leads to increased soil strength and results in stable aggregates [12, 13]. Conventional and conservation tillage has some set backs which includes decreased pore network and sometimes disruption of soil organisms which burrows through the soil [14] but over all, general positive effects is advantageous since favourable environment is created for crop growth and efficient nutrient usage [10].

No-tillage on the other hand, shows some contradiction to other tillage methods [5]. No-tillage was reported in arid regions as improving moisture preservation and there was an increase in income of about 13% more in no-tillage than other methods [15]. Since no-tillage consists of killing weeds on a field or planting cover crops with the main crop in trash of mulch, soil nutrients is improved and therefore there is a continuous addition of organic matter which provides nutrients for crop growth, development and yield [16].

Again, minimum tillage and hoe tillage is practiced in Ghana in some areas to improve soil physical properties and onward yield of crops. Due to these methods that are available and relevant to the improvement of melon production, there is the need to investigate into different tillage methods to ascertain their influence on soil physical properties, crop growth and yield. The objective of this study was to evaluate the effect of three land preparation methods on physical properties of soil, growth, development and yield of water melon in the forest transitional zone of Ghana.

2. Materials and methods

2.1 Description of Eexperimental site ~~and Location~~

Two field experiments were undertaken at the experimental site (Nursery) of the University of Education, College of Agriculture, Mampong-Ashanti. Mampong –Ashanti is located between latitude 07^0 – 08^0N and Longitude 01^0 – 02^0 W [17] (Mampong –Ashanti Meteorological Station, 2003). The site is situated within the transitional agro-ecological zone that is between the forest and Guinea Savannah zones.

This region has two rainfall regimes – the major season which occurs from April to July and minor one also occurs from August to October. The mean daily temperature is about 30^0C with monthly mean rainfall of 91.2mm. The total annual mean rainfall is estimated to be 1094.2mm. The soil of the Mampong –Ashanti belongs to the Bediase series and is deep sandy-loam, free from stones and red in colour and is of forest ochrosol type which was formed from voltain sandstone with pH between 5.5 to 6.5 [18].

Comment [R2]: Write in detail (e.g. *7^{0}02'23"N and 1^{0}22'10"W).*

2.2 Experimental design and Treatments

The field experimental design used was Randomised Complete Block design (RCBD) with 3 three replications. Three (3) ~~land preparation~~tillage methods were used, namely;

- No-tillage ~~Zero Tillage~~ (~~Z~~NT).
- Conventional Tillage with ~~P~~ploughing and harrowing (~~PH~~CT)
- Minimum tillage with ~~H~~hand hoeing ~~(Minimum tillage~~ (MT)

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Comment [R3]: Please standardize these definition for the treatments. These denomination are use throughout the world in scientific literature. Correct it by all the text.

2.3 Field lay-out

Total field used for the experiment was $576m^2$ (32m x 18m). Each main plot of Zero tillage (ZT) ploughing and harrowing (PH) as well as minimum tillage (MT) had a total length of 32m. There were four (4) rows for all the row spacing and each row had nine hills. The breadth of each plot measured ~~450cm (~~4.5m~~)~~ with ~~225cm (~~2.25m~~)~~. ~~One variety of watermelon was used thus Technisem (KAOLACK) treated with Thiram from Reiss and Co. Ltd.~~

Comment [R4]: It is strange. Write again. What was the size of each plot?

2.4 Management practices

Land preparations involved spraying ~~one plot~~ with Glyphosate 41% SL herbicide ~~thus~~ for zero tillage plots. The others ~~two~~ plots being ploughing and harrowing as well as ~~Hand~~ hand hoeing (Minimum tillage) ~~i.e. minimum tillage~~ were done at different dates in such a way that the weeds on the sprayed plot could die down to coincide with the other land preparations. Demarcation and pegging of plots were also carried out.

Comment [R5]: Describe in detail this how was done the tillage of this treatment. Kind of plough harrow, deep of tillage, etc.

Comment [R6]: Again, describe the method in detail.

2.5 ~~Planting or~~Watermelon sowing ~~of seeds~~

~~Sowing of the seeds for the two separate experiments~~ Watermelon ~~were~~was sown on 9th October, 2010 for the first year of the experiment and 29th August 2011 for second year.~~respectively.~~ In each case two seeds per hill were sown at the planting depth of 3-4cm and were later thinned to one. One variety of watermelon was used thus Technisem (KAOLACK) treated with Thiram from Reiss and Co. Ltd. What was the planting spacing between row and between plants?

There were four rows with nine (9) plants on each plot. Out of the four rows in each plot, the two (2) middle rows, six (6) plants were tagged for data collection. On the average, over 90% of the sown seeds germinated in five (5) days after ~~planting~~ sowing (~~5DAP~~5DAS).
Show the climatic data along the period of the experiments (2010 and 2011).

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2.6 Weed control

In both experiments, weeds were controlled by hoeing and hand pulling. The dominated weeds were *Cynodon plectostachys* (Giant star grass), *Euphorbia heterophylla* (milk weed) and Cyperus *rotundus* (Sedge). Weeds were controlled four times before harvesting. The first weed control was carried out in two weeks after ~~planting~~ sowing (~~14DAP~~14DAS). The rest of the weeding were carried out fortnightly till the fruits were ready for harvesting thus 2nd, 4th, 6th and 8th weeks respectively.
Earthing-up was done after every weed control to give plants extra support and also to expose any insect pest to be killed. The soil was frequently stirred to ensure ~~free circulation of air~~ soil gas exchange and to increase infiltration rate after watering.

2.7 Fertilizer application

During both the first and second experiments, there were two regimes of fertilizer application on the watermelon plants. The first application was two weeks after sowing using N.P.K. 15:15:15 with 50kgN, 30kg each P_2O_5 and per hectare as indicated by Yayock *et al*. [19].
9.72kg N.P.K. was applied on a total experimental area ~~of~~ (972 plants) on the 3rd week that is, each plant taking 7g of N.P.K. At fruiting thus around 6th week after planting, 14.58kg of Ammonium sulphate was applied on a total area at a rate of 15g plant^{-1} to a stand as reported by [20~~],].that watermelon requires more fertilizer application at fruiting stage.~~

Comment [R7]: It is confuse!! How much was applied of 15:15:15 (N:P:K)? When were applied 50 Kg N and 30 kg P2O5?

2.8 Disease and pest control

Effective disease control measures adopted in each of the experiment was the use of Diahane M-45 conti-zeb "5" 80% WP which was applied at the rate of 80g in 15litres of water in a knapsack sprayer on the (~~14DAP~~14DAS) and repeated three (3) times between 7-10 days of each application. Dosage of 500-1000 litres of water per hectare was recommended to check leaf spot and Downy mildew Bright.

Pest of watermelon mostly found were Grasshoppers, Crickets and fruit fly and were controlled by spraying with Cymethoate Super E.C using 100mls of the chemical for 15litres of knapsack with the recommended rate of 1-1.5 litre per ha. Four spraying were carried out on the 2nd, 4th, 6th and 8th weeks after planting.

2.9 **Harvesting**

Developing fruits were protected from soils insects by being raised on pads of grass. When the curly tendril on the leaf near the stem dried up which became brown, indicated maturity. Splittstoesser [21], indicated that a sharp metallic sound shows that watermelon fruit is not matured but a dully sound indicates maturity. On ~~of the 9th October, 2010 was harvested on the~~ 23rd December 2010 watermelon was harvested whereas the second farm ~~which started on the 29th August~~ was harvested on November 17th. ~~Developing fruits were protected from soils insects by being raised on pads of grass.~~

After harvesting, all fruits from each ~~harvestable area of~~ plot (six plants) were weighed and the average recorded. Total number of fruits ~~for~~ from each plot ~~were~~ was also recorded.

2.10 **Data collection**

2.10.1 Soil physical properties

The bulk density was determined by using the core method [22]. The samples of soil were taken from the selected sites of each plot using the core sampler. What depth in the soil profile was taken the sample?. The samples were weighed before and after drying in an oven at a temperature of 105°C for 24 hours. The dry bulk density was determined as follows:

Comment [R8]: How many sites?

$$\text{Bulk density (g cm}^{-3}) = \frac{W_1}{V_1}$$

Where: W_1 is the weight of the undisturbed oven-dried soil sample and V_1 is the volume of the soil which is equal to the volume of the core sampler.

The volumetric moisture content was calculated using the formula by [23].

$\theta v = (\theta)g \times BD/Dw$

where: θg is soil gravimetric moisture, BD is bulk density and Dw is density of water.

Soil porosity was determined using the formula [23] .

$f = (1\text{-}BD/PD) \times 100$

where: f = Total porosity

BD = bulk density

PD = particle density = 2.65g/cm^3 [24].

2.10.2 Vegetative growth of watermelon

2.10.2.1 Plant length

Plant length was measured from the soil level to the terminal bud using ruler. Recordings were taken on the 14DA~~P~~S, 28DAP, 42DA~~P~~S and 56DA~~P~~S. As the plants were growing, metre-rule-and
tape measure were used to take readings. All recording were in centimetres (cm) and mean values for the data were also determined.

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2.10.2.2 Number of leaves

The number of leaves within the harvestable or tagged plants was counted fortnightly from 14DAP, 28DAP, 42DAP and 56DAP. Average ~~or mean~~ for the recordings ~~were~~ was taken.

2.10.3 Yield and yield components of watermelon

2.10.3.1 Number of watermelon fruits ~~per plot~~

Total number of fruits ~~in the harvestable area~~from the selected plants of each plot was counted and the number recorded as the number of fruits per plot.

2.10.3.2 Mean weight of ~~crops~~watermelon fruit

Weight of individual ~~crops~~ fruit from selected plants from ~~on~~ each ~~treatment~~plot was weighed and the mean values taken in kilogrammes (kg).

2.10.3.3 Circumference of the watermelon fruits

Individual fruit~~s~~ from the tagged plants ~~were~~ was measured using ~~T~~tape measure in centimetres (cm).

2.10.3.4 Yield of watermelon fruits

Yield of fruits harvested from the ~~middle~~ selected rows were countered and weighed to ~~obtain~~ measure the yield.

2.11 **Data analysis**

Data collected was analysed using analysis of variance (ANOVA) technique with SAS statistical package [25] and the means were separated using LSD at 0.05 (5%) probability level.

3. Results and discussion

3.1 Soil physical properties

Table 1 shows soil physical properties in 2010 and 2011 seasons. The results of the study in both ~~2010 and 2011~~ seasons indicates that, tillage method significantly affected soil physical properties as they decreased soil bulk density, increased moisture content and total porosity for the two tillage treatments, conventional tillage (CT) and minimum tillage (MT) ~~tillage treatments~~ while the ~~zero~~ no-tillage recorded higher bulk density with lower porosity and moisture content (Table 1). Soils of the ~~plough~~ CT and ~~harrowed~~ MT consistently showed superiority by having the highest volumetric water content (moisture) (23.28%, 25.23%), lower bulk density of 1.12 and 1.14 and a total porosity of 59.23% and 57.26% respectively in the two growing seasons (Table 1). Alternatively, the no--tillage treatment recorded the lowest moisture (12.36%, 17.29%) and lower porosity of (54.84, 55.77) respectively and a higher bulk density of (1.20 and 1.19). The improvement in the ~~ploughed and harrowed~~CT treatment physical properties could be due to the effect of the ~~breaking of soil lumps and levelling of soil~~disrupting soil structure which made the soil smooth and loose with fine textured which improved porosity and water holding capacity of the soil. Khurshid *et al*. [3] reported that tillage methods normally increased soil moisture content and porosity with lower bulk density which has positive impact on crop growth and yield. The present study is in line with the observation made by Khurshid *et al*. [3]. There have been several studies which have revealed that soil moisture increases with soil depth which is function of degree of tillage. The present study is in line with the findings made by Ji *et al*. [26] who observed that moisture retention increases when deep tillage is applied which can simply mean that ploughing and harrowing (CT) can be combined to achieve good results on soils properties. It was clearly observed in the present study that as ~~harrowing~~ CT was done, the soil became fine textured which enabled the soil to contain more water than the zero tillage. This means that ~~there were~~was improved infiltration of water ~~and percolation~~ which invariably made nutrients available and accessible to the roots of plants of ~~water melon~~watermelon in the two growing seasons. Hulugale *et al*. [9] is of the view that tillage method loosens and improves percolation while conservation and no-tillage leaves the soil intact because the soil is not disturbed. Khan *et al.* [10] also observed that conventional tillage method produces a favourable environment for crop growth and nutrient use. This assertion is in line with the observation made in the present study.

Comment [R9]: What methods?

Table 1: Effect of different tillage on soil physical properties (2010 and 2011)

Treatment	Bulk density (g/cm)		Total porosity (%)		Volumetric water content (%)	
Tillage	2010	2011	2010	2011	2010	2011
~~Zero~~ No-Tillage	1.20a* 1.19 ~~1.19~~		54.84	55.77	12.36	17.29
~~Plough~~Conventional tillage	1.12b ~~1.14~~	1.14	59.23	57.26	23.28	25.23
Minimum Tillage	1.13b ~~1.18~~	1.18	57.77	56.76	19.74	22.94
LSD (0.05)	0.01	0.04	2.46	0.33	1.28	1.81
CV	0.40	1.00	1.60	0.10	3.20	4.10

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.2 Mean Vine Length ~~(cm)~~ of watermelon

Table 2 below shows the mean vine length from 14 DA~~P~~S, 28DA~~P~~S, 42DA~~P~~S and 56 DA~~P~~S. For the vine length, ~~ploughed and harrowed~~conventional tillage (CT) recorded the highest (193.81cm) for 2010 and 230.47cm for 2011 whereas the lowest vine length was recorded by minimum tillage (186.96cm) for 2010 and 223.84cm for 2011 ~~during~~ at the last sampling stage, ~~(~~56 DA~~P~~S~~)~~(Table 2). Is there significant difference in another evaluation dates (14, 28 and 42 DAS – these results must be write here. There were significant differences among the tillage methods employed in the study. The highest plant vine length recorded by ~~the ploughed and harrowed~~CT treatment was influenced by ~~the tillage methods employed in the study~~ the improvement in soil properties. Dauda and Maina [6] observed that, plant length was affected by the tillage methods employed in planting. The mean vine lengths obtained agrees with the assertion made by [22] that watermelon plants grow from 1.5-5.0m length. Again, the ~~zero~~ no-tillage performed creditably well and might be attributed to the weeds which served as mulch after spraying which improved the moisture content of the soil. This is in agreement with Aina *et al.* [16] that, the material or trash formed after killing the weeds serves as mulch and conserve moisture for crop growth.

Comment [R10]: Rethink. In your results the soil moisture decrease in No-tillage treatments. Indeed the No-tillage improve soil moisture as related several scientific reports, but in this case the results is unfavorable to no-till regarding soil water holding. So, you must discuss better this fact.

Table 2: Effect of different tillage on vine length (cm) of watermelon (2010 and 2011)

Treatment	14 DAP		28 DAP		42 DAP		56 DAP	
Tillage	2010	2011	2010	2011	2010	2011	2010	2011
Zero Tillage	14.75	15.14	88.40	96.80	132.03	145.77	193.01	229.64
Plough	15.90	17.10	89.70	98.61	132.13	146.17	193.81	230.47
Minimum Tillage	15.21	15.67	85.70	96.82	131.60	145.76	186.96	223.84
LSD (0.05)	0.68	0.01	0.46	0.02	0.07	0.02	0.001	0.002
CV	1.20	0.10	1.50	0.01	0.01	0.001	0.02	0.01

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.3 Evaluation of watermelon ~~N~~number ~~of L~~leaves ~~(NLV) Evaluation~~

Table 3 ~~below~~ shows the watermelon number of leaves recorded fortnightly on ~~the number of leaves produced by~~ the plants from the treatments of tillage methods. The treatment of the ~~ploughed and harrowed~~conventional tillage (CT) ~~land~~ had the highest number of leaves (22.12) in the year 2010 and 26.13 in 2011 at the last sampling stage, 56 DAS. The lowest number of leaves was recorded by minimum tillage in both two growing seasons thus 21.16 and 25.41 for 2010 and 2011 respectively (Table 3). The highest number of leaves recorded by the ~~ploughed land~~CT might be due to the infiltration rate and ability of the soil to conserve moisture after the ploughing and harrowing was done. This breaks the soil aggregates and increased porosity which improves water retention for plant growth. Claasen [27] on tillage methods suggested that soil moisture conserves best on how deep either the mouldboard or disc plough will cut into the soil. Again, [7] reported that among the functions and reason why farmers invest labour and money in tillage was to increase water infiltration to enhance soil moisture storage and reduce run-off and to control insect pests in soil.

Comment [R11]: There are several scientific results now a day that drives contrary to this statement. It is consensus within agriculture academic for the improvement in soil properties under Conservation Agriculture (no tillage or minimum tillage, crop rotation and permanent residue on soil surface). Thus the authors should based better in current researches for then defense the results achieved in this research.

Table 3 Number of Leaves (NLV) (2010 and 2011)

Treatment	14 DAP		28 DAP		42 DAP		56 DAP	
Tillage	2010	2011	2010	2011	2010	2011	2010	2011
Zero Tillage	6.09	6.35	9.02	11.74	16.44	17.73	21.18	25.64
Plough	6.11	6.43	9.04	11.83	16.68	18.11	22.12	26.13

Minimum Tillage	6.25	6.69	9.15	11.95	16.68	17.72	21.16	25.41
LSD (0.05)	0.008	0.001	0.06	0.01	0.33	0.26	0.001	0.010
CV	0.20	0.20	0.10	0.10	0.50	0.30	0.00	0.00

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Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.4 Mean Watermelon Yield Components (- Number of fruits/plot, Wt. per Fruit (kg) and Circumference per Fruit (cm)

3.4.1 Mean nNumber of fruits /plot of watermelon per plot (2010 and 2011)

Mean nNumber of fruits of watermelon /plot is are presented in Table 4. For 2010 season, the plough conventional tillage (CT) recorded the highest number of fruits (with 27.33) followed by the minimum tillage (MT) with (24.33) with and the zero no-tillage (NT) recording the lowest (fruit number with 24.11)per plot. In 2011 season, same trend was recorded, the highest number of fruits was recorded by the plough (27.89) followed by the minimum tillage (27.00) with zero tillage again recording the lower number (26.22) of fruit (Table 4). There were significant differences among the treatments in all the seasons. Number of fruits and other components are influenced by the tillage methods applied to the soil before planting. Ploughed and harrowed and minimum tillage methods disturbs the soil and improves physical properties of the soil which reduces penetration resistance and improves nutrient uptake and water movement and holding capacity which in turn favoured growth pattern and number of fruits. Keshavarzpour [28] observed that, tillage methods employed in water melon production produced more fruits than no tillage due to the influence it had on soil physical properties. These assertions influenced the results on the number of fruits obtained in the present study.

Table 4: Mean nNumber of fruits per plot of watermelon /plot (2010 and 2011)

TREATMENT	2010	2011
Tillage		
Zero Tillage	24.11	26.22
Plough	27.33	27.89
Minimum Tillage	24.33	27.00
LSD(0.05)	0.013	0.01

CV (%)	0.01	**0.02**

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.4.2 ~~Mean~~ Fruit weight per plot of ~~fruit/plot~~watermelon (kg)

For the mean weight per fruit, it was observed that in 2010 the ~~ploughed land~~ conventional tillage ~~(~~CT) recorded the highest (2.12kg) and was followed by the minimum tillage (MT ~~(~~ with 2.05kg~~)~~ and the lowest was recorded by ~~zero~~ no-tillage (NT) with ~~(~~1.96kg~~)~~. Similar ~~trend continued~~ ranking was found in 2011 growing season where ~~the ploughed and harrowed~~CT recorded the highest weight per fruit of 5.03kg and was followed by the ~~minimum tillage~~MT (4.03kg) whilst the ~~zero tillage~~NT recorded the lowest fruit weight (3.59kg). In 2010, no significant difference was obtained at probability (0.05), among the ~~plough~~ CT and ~~minimum tillage~~MT but there was a significant difference between the ~~plough~~ CT and ~~zero tillage~~NT. However, in the 2011 season, there was a significant difference between the treatments at (p>0.05) (Table 5). Keshavarzpour and Rashidi [8] ~~observed~~ reported that tillage methods significantly affected crop yield, fruit weight, vine length and fruit length of water melon. Their ~~observation~~ reports is consonant with the present study which revealed that, fruit weight of ~~tillage methods~~CT was higher than the ~~no tillage~~NT which is attributed to the soil preparation which improved nutrient uptake and infiltration rate of ~~ploughed~~ CT and ~~minimum tillage~~MT than the ~~no tillage~~NT where infiltration and nutrient movement would be limited due to undisturbed nature of the soil. Again, the present study confirms Rashidi and Keshavarzpour [29], work on the differences in fruit weight among the tillage methods. In 2010, of this study, the ~~ploughed and harrowed~~CT and the ~~minimum tillage~~MT had the highest fruit weight than the ~~zero tillage~~NT but there were no significant differences ~~among~~ between them and attributed the differences observed to tilth of the soils than the ~~zero tillage~~NT which influenced other soil physical properties.

Table 5: ~~Mean w~~Weight ~~of~~ fruit per ~~/~~plot (kg) of watermelon (2010 and 2011)

Treatment	2010	2011
Tillage		
Zero Tillage	1.96	3.59
Plough	2.12	5.03
Minimum Tillage	2.05	4.03

LSD (0.05)	0.10	0.07
CV	0.50	0.60

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.4.3 Circumference of fruits (cm)

For the meanRegarding to circumference per fruit, the ploughed and harrowed conventional tillage (CT) recorded the highest value of 26.44cm followed by the minimum tillage (MT) of 25.44cm and the least recorded by the zero no-tillage (NT) (with 24.66cm). There was significant difference between the treatments. The 2011 cultivation witnessed the ploughed and harrowedCT again recording the highest (value with 66.11cm) followed by the minimum tillageMT with (61.22cm) and the least was recorded by zero NTtillage (with 58.44cm).There were significant differences between among the treatments (Table 6).

These differences recorded among by the tillage methods than the no-tillage method could be due to the fact that the tillageCT method provided a favourable environment for the growth of the fruit and this is because, the disturbance and the pulverization of the soil made the soil loose and provided an avenue for root and plant growth and consequently fruit growth and enlargement of the fruit which resulted in the larger sizes and onward yield of the watermelon fruit. The current study agrees with Khan *et al.* [10], who observed that conventional tillage method produces a favourable environment for crop growth and nutrient use. Again, Rashidi and Keshavarzpour [11] reported that annual disturbance and pulverizing caused by conventional tillage method produce a finer and loose soil structure which in turn affect the seedling emergence, plant population density and consequently crop yield.

Table 6: Mean fFruit circumference /plotof watermelon (cm) in (2010 and 2011seasons)

Treatment	2010	2011
Tillage		
Zero Tillage	24.66	58.44
Plough	26.44	66.11
Minimum Tillage	25.44	61.22
LSD(0.05)	0.001	0.10

CV (%)	0.01	**0.02**

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

3.4.4 Fruit yield of watermelon (~~kg/ha~~Mg ha^{-1})

Comment [R12]: Change the unit for Mg ha-1. This unit is universal for yield.

For the yield of fruits per hectare, the following values were recorded for 2010 growing season; the ~~ploughed and harrowed~~conventional tillage (CT) yielded (~~43,364~~.3 Mg ha^{-1}~~kg/ha~~), minimum tillage (MT) (~~32,.5531kg/ha~~Mg ha^{-1}~~)~~ and ~~zero~~ no-tillage (NT) (~~28,.210kg/ha~~Mg ha^{-1}~~)~~. The 2011 growing season also recorded the following; ~~ploughed and harrowed~~ CT yielded (~~96,.157kg/ha~~Mg ha^{-1}~~)~~, ~~minimum tillage~~MT (~~65,.840kg/ha~~Mg ha^{-1}~~)~~ and the ~~zero tillage~~NT (~~55,.051kg/ha~~Mg ha^{-1}~~)~~ (Table 7). The differences in the yield of watermelon fruits could be attributed to the tillage practices embarked on during the experiment. It is stated that, ~~ploughing or tilling the land~~CT had influence on the seed germination, growth and onward yield of watermelon. This is because, physical attributes of the soil are enhanced which also helps in nutrient uptake than undisturbed soils which are often hard and affects penetration of ~~seed~~root, growth and yield. This observation has been made by Keshavarzpour and Rashidi [8] who stated that ~~tillage~~ CT methods significantly affected crop yield, fruit weight, vine length and fruit length of water melon. Again, the current study is in line with Khan *et al.* [11], who observed that conventional tillage method produces a favourable environment for crop growth and nutrient use. Also, [11] reported that annual disturbance and pulverizing caused by conventional tillage method produce a finer and loose soil structure which in turn affect the seedling emergence, plant population density and consequently crop yield.

Table 7: ~~Mean yield~~ Yield of watermelon fruit (~~kg/ha~~Mg ha^{-1}) (~~throughout~~ 2010 and 2011~~)~~seasons

TREATMENT	**2010**	**2011**
Tillage		
Zero Tillage	28.2~~10~~	55.0~~51~~
Plough	43.3~~64~~	96.1~~57~~
Minimum Tillage	32.5~~31~~	65.8~~40~~
LSD(0.05)	8.611	19.306
CV (%)	17.92	**13.66**

*Different words in column means significant difference between values

Please put the words for indicate significant difference between treatments in all Table of the manuscript.

4. **Conclusion**

Tillage method significantly affected soil physical properties thus total porosity, volumetric water content and bulk density. Also, tillage methods influenced crop growth, yield and yield components of watermelon in the order of ~~Plough~~ Conventional tillage > Minimum tillage > No-Tillage. These observation made is mainly due to the favourable soil environment provided by the tilled land which improved soil physical abilities for improved growth and yield. It is recommended that for effective growth and yield of water melon in forest transitional zone, tillage practices such as ploughed and harrowed and minimum tillage is better than the no-tillage method.

REFERENCES

1. De Lannoy Plant resources of tropical Africa 2 (PROTA). Vegetables Prota Foundations/2001. Back Huys Publishers/CTI. Wegeningen, Nertherlands (2004)

2. Sinnadurai, S. Vegetable production in Ghana. Asempa Publishers Ltd. Accra Ghana, 1992. pp 208

3. Khurshid, K., Iqbal, M., Arif, MS. and Nawaz, A.. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agri. Biol., 2006. 5: 593-596.

4. Lal, R. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. Soil and Tillage Res., 1993. 51: 61-70.

5. Iqbal, M Hassan AU. Ali A. and Rizwanullah M. Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). Int. J. Agri. Biol., 2005. 1: 54-57.

6. Dauda, A and Maina, KD Effects of tillage methods on some soil physical properties, growth and yield of water melon in a semi-arid region of

Nigeria. Arid Zone Journal of Engineering, Technology and Environment. February, 2017. Vol. 12 (13): 54-65. ISSN 2545-5818.

7. Steiner, K. Conservation Tillage-Gateway to food security and sustainable rural development impact of conservation tillage on soil quality. Africa conservation tillage network. (2002) Information series No.4

8. Keshavarzpour F, Rashidi M. Effect of different tillage methods on soil physical properties and crop yield of watermelon (Citrullus vulgaris). World Appl. Sci. J. 2008;3:359-364.

9. Hullugale, NR, Lal, R. and Gichuru, M. Effect of five years of No tillage and mulch on soil properties and tuber yield of cassava on an acid Ultisol soil in South Eatern Nigeria. Experimental Agric, 1990. 26:235-240.

10. Khan FUH, Tahir, AR. and Yule IJ. Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. Int. J. Agri. Biol. 2001. 1: 23-26.

11. Rashidi M. and Keshavarzpour F. Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). Int. J. Agri. Biol. 2007. 2: 274-277.

12. Bauder, JW, Randall GW. and Swan JB. Effects of four continue tillage systems on mechanical impedance of a clay-loam soil. Soil Sci. Soc. Amer. J. 1981. 45: 802-806. Cannel R.Q. 1985. Reduced tillage in north-west Europe - a review. Soil and Tillage Res., 5: 129-177.

13. Horne DJ, Ross CW. and Hughes KA. Ten years of maize/oats rotation under three tillage systems on a silt loam soil in New Zealand. 1. A comparison of some soil properties. Soil and Tillage Res. 1992. 22: 131-143.

14. Hill, RL. Long-term conventional and no-tillage effects on selected soil physical properties. Soil Sci. Soc. Amer. J. 1990. 54: 161-166.

15. Ghuman, BS. and Lal R.. Water percolation in tropical Alfisol under conventional ploughing and notillage systems of management. Soil and Tillage Res. 1984, 4: 263-276.

16. Aina, P O. Lal, R. and Roose, EO. Tillage methods and soil water conservation in West Africa. Soil and Tillage Research 1991. 20: 165-186

17. Mampong –Ashanti Meteorological Station, 2003

18. Asiamah, RD. Soils and soil suitability of Ashanti Region. Soil Research Institute –CSIR, Kwadaso, Kumasi; Technical Report No. 193. 1998.

19. Yayock, JY. Lombin, G J.J. and. Onazi, CO. Crop science and production in warm climate. 1988. Publishers, Macmiillan Ltd. London and Basingstone.

20. Messian, CM. The tropical vegetable garden principle for improvement and increased production. 1994. Apply to the main vegetable types. Reprinted in 1994 in Hongkong. Macmillan Press Ltd.

21. Splittstoesser, WE. Vegetable growing handbook: organic and traditional method. 3rd Edition. 1990 Van Nostrand, Reinhold, New York, USA.

22. Blake, GR. Particle density. In: *Methods of soil analysis*.1:371-373. Agronomy Science No. 9. American Society of Agronomy 1965. Inc. Madiso, Ulisconsm, USA.

23. Hillel, D. Applications of soil physics. Academy Press, New York. 1980. pp. 385.

24. Statistical Analysis System Package, 1999 Edition.

25. Food and Agricultural Organisation, of United Nations *FAO* Fertilizer and Plant Nutrition Bulleting 19 .2008 .

26. Ji B. Yuanjun Z. Mu X. Liu K. Li C. Effects of tillage on soil physical properties and root growth of maize in loam and clay in central China. Plant Soil and Environment Journal 2013.59 (7):295-302 DOI:10.17221/57/2013-PSE.

27. Claasen, LS. Mechanical, minimum and No- tillage crop production for research Farms 117A Research Guide 1996 No. 113

28. Keshavarzpour, F. Effect of Different Tillage Methods on Crop Yield and Yield Components of Watermelon. Academic Journal of Plant Sciences 6 (2): 99-102, 2013. ISSN 1995-8986. DOI: 10.5829/idosi.ajps.2013.6.2.340 .

29. Rashidi, M. and Keshavarzpour, F. Effect of different tillage methods on yield and yield components of forage corn. *Am-Eurasian Journal of Agriculture and Environmental Sciences*. 2011. 3:301-310.