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EFFECTS OF TILLAGE METHODS ON SOME SOIL PHYSICAL PROPERTIES, GROWTH AND YIELD OF WATER MELON IN A SEMI ARID REGION OF NIGERIA

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Abstract
An appropriate tillage method is necessary to create an optimum seed bed condition for optimum crop growth and yield. Two-year field experiment was conducted in 2013 and 2014 to investigate the effects of different tillage methods on the physical properties of sandy loam soil, growth and yield of water melon *(Citrullus vulgaris)* in a semi-arid environment. The Tillage treatments were disc ploughing plus disc harrowing (DP+DH), double disc ploughing (DDP), double disc harrowing (DDH), disc ploughing (DP) and disc harrowing (DH) as minimum tillage (MT) and zero tillage (ZT) and direct drilling method (control). The watermelon seeds were Planted manually placing three (3) seeds per hole at an interval of 1.5m along the rows and 50cm between the rows at an average depth of 5cm. The treatments were laid in a randomized complete block design (RCBD) with four replications. Results showed that disc ploughing + disc harrowing (DP+DH) was found to be more appropriate and profitable tillage method in improving soil physical properties and growth and yield of water melon in a sandy loam soil. Watermelon yield, fruit weight (FW), fruit length (FL), fruit diameter (FD) and leaf area index (LAI) were significantly influenced (P=0.05), but influence of tillage treatments were not significant on the number of fruit per plant (NFPP). A numerical value of 31.0t/ha, 26.0, 5.4kg, 29.0cm, and 33.8cm were recorded for maximum crop yield, NFPP, FW, FD and FL respectively in DP+DH-treated plots. For zero tillage (ZT) treatment, maximum of crop yield and NFPP were 26.5t/ha and 20.0 respectively. Thus for enhanced growth and yield of watermelon, DP/DH would be more preferable. The orthodox method of zero tillage is out rightly discouraged

Key words: Tillage methods, Sandy loam Soil, Water melon, semi-arid region

1. Introduction
Watermelon (*Citrullus vulgaris)* is one of the most important vegetable crops in Nigeria, and is well adapted to most soils and climatic conditions (Nkakino *et al.*, 2008). In Nigeria, though there are no official figures recorded for its production, the crop has a wide distribution as a garden crop; while as a commercial vegetable production, its cultivation is confined to the drier savannah region of Nigeria (Anon, 2006). Although, the use of improved varieties and fertilizers has increased the production of water melon, the full potential of the crop's production has not yet been achieved (Ibrahim *et al*, 2014).

Tillage operations are conventionally carried out to manipulate soil to develop a desirable soil structure for a seedbed and good surface configuration for crop planting (Aluko and Lasisi, 2009; Nkakino *et al.*, 2008). Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% of crop production factor (Khurshid *et al.,* 2006); Hammel, 1989; Rashidi and Keshavarzpour, 2007). Despite the above, the influences of various tillage methods on the production of watermelon in this region have received adequate analysis.

The main objective of the study is to evaluate the effectiveness of common tillage practices in improving soil physical conditions, and on growth and yield of watermelon (*Citrullus vulgaris*) in a semi-arid environment. This study will provide suggestion to farmers on the appropriate tillage system combined with crop growth and yield to enhance growing of water melon on sandy loam soils in the semi-arid region of Nigeria.

2 Materials and Methods

2.1 Experimental Site

This study was carried out at the Department of Agricultural and Environmental Resources Engineering Research Farm of the University of Maiduguri. Maiduguri is the capital city of Borno state of Nigeria, located between latitude 11^{o} 15' N and longitude 10^{o} 25' E in the northeastern sub-region of Nigeria. The soil of the research farm had earlier been classified as Typic Upstisanment (Rayar, 1984) with Aeolian sand formation and is weakly aggregated. The soil has a sandy loam texture and is made up of 6% silt, 17% clay and 77% sand (Ohu *et al*., 1989). The study was conducted during the rainy seasons of 2013 and 2014. Mean maximum and minimum temperatures were 22 and 40^{o}C, while the relative humidity and mean annual rainfall were 30 % and 500 mm respectively.

2.2 Experimental Design.

Experimental field was 85 m long and 55 m wide to form an area of 4675m^2. This field was sub-divided into 24 plots that were 100 m^2 each with alleys of 5m between the plots. Treatments considered in the study consisted of six different tillage treatments, designated as zero tillage (ZT)(control), Disc Harrow (DH), Disc Plough (DP), Double Disc Harrow (DDH), Double Disc Ploughing (DDP) and Disc Ploughing plus Disc Harrowing (DP/DH). The treatments were laid in a Randomized Complete Block Design (RCBD), with four (4) replications. A Massey Ferguson (MF 375) tractor with 31.0kpa contact pressure was used for the tillage operations.

The field was cleared and laid out before the treatments were applied on 10th September, 2013 and 15th August, 2014 respectively. Disc ploughing was done at an average depth of 30cm with a 3-furrow mounted disc plough having 65cm-disc diameter. Harrowing was achieved with an offset disc harrow at an average depth of 15cm with 55cm-diameter discs. Zero tillage involves planting on bare land with no soil disturbance, whereas the other treatments were carried out by ploughing followed by harrowing using the above implements. Watermelon seeds of Sisico variety (Khan *et al*., 2001) were planted on the 14th September, 2013 and 19th August, 2014 following a rainfall the preceding day. Planting was done manually by placing three (3) seeds per hole at an interval of 1.5m along the rows and 50cm between the rows at an average depth of 5cm. Weeding were carried out manually at 3, 7 and 12 weeks after planting (WAP) Ohu *et al.* (2006).

2.3 Measurements of soil parameters

The soil bulk density was determined from undisturbed soil samples using the core sampling method as modified by Blake and Hartge (1986). Core samples were taken for the bulk density determinations before and after treatment application and at different stages of plants growth viz-a-viz at initiation, development, mid-season and late season stages. The penetration resistance was determined using a penetrometer having a cone base diameter of 15mm and cone angle of 60^{o} operating at 1829mm^{-1} (ASAE, 1984) at the depth of 30cm. The treatments were applied to the same plots during the two years on farm study. Soil moisture content was determined gravimetrically by oven-drying a pre-weighed moist soil sample at 105^{o}c for 24hours and reweighing, the moisture content was calculated as percentage of the ratio of mass of water lost to the mass of the dried soil (Ibrahim, 2013).

2.4 Measurement of plant's growth parameters

The number of days to 50% germination was determined by counting when 50% of the plants have germinated in each plot**.** Plant length was measured using a meter rule from the ground level to the tip of the longest leaf during vegetative growth from each plot at 3, 6, 9, and 12 WAP. The lengths and widths of 10 randomly selected leaves on each branch were measured using ordinary tailor's tape to obtain the leaf area. The leaf areas were multiplied by factor 0.76 to arrive at the leaf area index, as reported by Chen and Black (1992). Mathematical expression of leaf area index (LAI) equals one half the total leaf area per unit ground surface area is being used (Chen and Black, 1992).

2.5 Yield Parameters

The number of days to 50% flowering was determined when 50% of the plants have started flowering, at least one another in each plot. This was done by regular observation of the growth parameter at least once in a week until when 50% flowering was achieved based on the number of plants per plot. The number of days to physiological maturity was determined when 50% of the fruit have reached maturity stage in each plot. The number of fruits per plant (NFPP), fruit length (FL), fruit diameter (FD), and fruit weight (FW) were measured from fruits of 10 randomly selected plants from each plot (Khurshid *et al.* 2006). The number of fruits per plant (NFPP) was obtained by visual counting of fuits on the 10 randomly selected plants. The FD determined using an electronic weighing balance and the average recorded (Doss *et al*., 1980; Jain *et al*., 2000). The fruit diameter was determined by the tailor's measuring tape. The harvested fruits from the 10 randomly selected plants from each plot were weighed and the value obtained was converted to t/ha basis to arrive at the yield.

2.6 Statistical analysis

All data collected were subjected to Analysis of variance (ANOVA) using the statistical package for social sciences (SPSS) software version 16.0 to compare the significance of the differences between the treatment means. Mean separation was done using Duncan's multiple range test (DMRT). Regression analysis was also employed for developing models. Multiple regression analysis was employed to develop a model for predicting or assessing the effect of different tillage methods on the yield of watermelon in the study using data generated over the two-years (2013 and 2014) study period.

3. Results and Discussion

Table 1 shows the influences of the tillage treatments on soil moisture content (%) in the study area. The highest soil moisture contents were obtained in plots that received disc ploughing plus disc harrowing (DP/DH) and the lowest occurred as a result of the zero tillage (ZT) treatment. The soil moisture content that occurred due to disc ploughing plus disc harrowing (DP/DH) treatment was significantly different than those obtained from other treatments. This was attributed to the combined effect of primary and secondary tillage implements used in the tillage operations, which improved the porosity and the water holding capacity of the soil. These results are in agreement with those reported by Khan *et al*. (1999) that DP/DH increased the moisture content of the soil. Several studies have revealed that soil moisture increases with soil depth which is function of degree of tillage. This result is also in line with the findings by Yusuf *et al.* (2012) and John *et al.* (2013) that indicated that moisture retention increases with the combined influence of ploughing and harrowing.

Table 1: Influence of tillage treatments on soil moisture content of the study site

	Moisture content (%)	
Treatments	2013	2014
ZT	45^{d}	44^{d}
DH	46^{c}	46^{c}
DP	47^{b}	48^{b}
DDH	48^{a}	50^{a}
DDP	50^{a}	51^{a}
DP/DH	52^{a}	53^{a}

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan's Multiple Range Test (DMRT).

3.2 Bulk Density

Table 2 shows effects of different tillage methods on bulk density (Mg/m^3) of sandy loam soil in the study area. The Table revealed that different tillage treatments significantly affected soil bulk density in the study area. The highest mean soil bulk density of 1.79 and 2.20 Mg/m^3 was found in plots that received disc plough/disc harrow (DP/DH) treatments and the lowest soil bulk density of (1.38 and 1.41Mg/m^3) was found in plots with zero tillage (ZT) for the year 2013 and 2014. This is in line with Elder and Lal (2008); and Sharma *et al*. (2012). It is clear that the bulk densities increased with tillage depths in all tillage treatments. These finding which refer to the bulk densities at a given depth agree with those of Koyombo *et al.* (2002) who reported that soil bulk density increased with depth of tillage which is an implicit function of type of tillage.

Table 2: Effects of different tillage methods on soil bulk density (Mg/m^3) of sandy loam soil

Treatment	Cropping seasons	
	2013	2014
Zero tillage (ZT)	1.41^{e}	1.38^{e}
Disc harrow (DH)	1.52^{d}	1.55^{d}
Disc plough (DP)	1.58^{d}	1.59^{d}
Double disc harrow (DDH)	1.67^{c}	1.65^{c}
Double disc plough (DDP)	1.72^{b}	1.71^{b}
Disc plough + disc harrow (DP/DH)	1.79^{a}	1.78^{a}

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan's Multiple Range Test (DMRT).

3.3 Penetration Resistance

Table 3 shows effects of different tillage methods on penetration resistance (Mpa) of sandy loam soil in the study area The Table indicates the highest soil penetration resistances of 2.20Mpa in 2013 and 2.22Mpa in 2014 were obtained in the zero tilled (ZT) plots and the lowest 0.61 Mpa in 2013 and 0.71Mpa in 2014 due to combined effects of disc plough followed by disc harrowing. The difference in penetration resistance observed could be due to amount of moisture retention. These results are in agreement with those of Khan *et al*. (2001) who concluded that (DP/DH) lowered the soil penetration resistance than the zero tillage (ZT) treatment. This is in line with the results reported by Ghuman and Lal (1984) that penetration resistance decreased with increase in soil moisture content and vice versa. The kind of results reported is expected because after load application from tractor traffics, ploughing which is primary tillage operation will break the soil that will result in larger clods since the soil had been compacted. It is expected that the depression of the penetrometer probe into the soil will be affected by over-burden pressure from the soil which will lead to high penetration values. Harrowing as secondary tillage is expected to produce better tilth than ploughing and hence the reduction in penetration resistance compared to ploughing.

Table 3: Effects of different tillage methods on penetrating resistance (Mpa) of sandy loam soil

Treatments /Cropping seasons	2013	2014
Zero tillage (ZT)	2.20[a]	2.22[a]
Disc harrow (DH)	1.73[b]	1.71[b]
Disc plough (DP)	2.08[a]	2.08[a]
Double disc harrow (DDH)	1.45[c]	1.49[c]
Double disc plough (DDP)	1.96[b]	1.94[b]
Disc plough + disc harrow DP/DH)	0.61[d]	0.71[d]

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan's Multiple Range Test (DMRT).

3.4 Growth Parameters

3.4.1 Numbers of days to 50% germination, flowing and maturity

Table 4 shows the growth parameters of water melon as affected by the different tillage methods. The Table revealed that different tillage methods have greatly affected durations to 50% germination, flowering and maturity in 2014 compared to 2013. For instance, under ZT treatment, there were 2, 2, and 9 days increase of numbers of days to attain 50% germination, flowing and maturity respectively in 2014 over and above those in 2013. Similarly, treatment DP/DH had caused a shooting of the numbers of days to 50% germination, flowing and maturity by 2, 5, and 4 respectively in the year 2014 relative to those found in 2013. But the treatments generally had significantly (P = 0.05) affected these growth parameters. It was found that plants in the plots that received DP/DH tillage treatment attained maturity on the average of the 80th day after planting compared to those plots that received ZT tillage treatment that spent only average of 53 days to attain maturity. Similarly DP/DH had resulted into an increase of 7 and 26 days to achieve 50% germination and flowering respectively compared to those found under the influence of ZT treatment. These results tally with the reports of Asare *et al*. (2011), Khan *et al*. (2001); and Rashidi and Keshavarzpour (2007).

3.4.2 Leaf Area Index (LAI)

Tables 5 show the Leaf Area Index (LAI) at 3 to 12 weeks after planting (WAP) for 2013 and 2014. The influence of the tillage treatments in the LAI of watermelon was not significantly different in the 3rd and 6th WAP in both 2013 and 2014 cropping seasons. However, some significant differences were observed among the tillage treatments in the 6th and 9th WAP. In 2013, at 9th and 12th WAP, treatment DP/DH translated to LAI of 20.3 and 12.8. These values were significantly greater than the LAI that resulted from all other treatments. Similar trend were observed in the 2014 cropping season. This implied that variation in tillage would not manipulate the growth of watermelon at early stages of growth, but would cause differences in the growth at later stages of growth.

3.4.3 Plant length (m)

The plant length of watermelon for 3 to12 WAP observed during the study period is presented in Table 6. The results revealed that the plant length (m) for the period of 3-12 weeks increased with time as expected. There were significant variations in plant length among the different tillage treatments in which DP/DH caused the highest plant length and ZT lowest. Generally, the influence of the treatments on plants length decreased in the order of DP/DH>DDP>DDH>DP>DH>ZT in both cropping seasons. The reason could be due to the differences of compaction arising from the different tillage methods that modified the soil structure and thus variations in the soil environment for the crops to grow in. similar results were reported by (Ohu and Folorunso, 1989). Nonetheless, the plants heights 2014 were higher than those recorded in 2013. This is attributed to the high moisture content was observed in the year 2014. From the literature it can be observed that tillage operations generally loosens the soil, increases soil bulk density and penetration resistance by increasing soil macro porosity (Moreno *et al*. 2001).

3.5 Yield Parameters

3.5.1 Number of fruits per plant (NFPP)

Table 7 shows the effect of different tillage treatments on number of fruits per plant (NFPP). The Table indicates that highest number of fruits per plant (16 and 26) in 2013 and 2014 respectively came as result of DP/DH treatment, while the lowest values of 4 and 6 were found in plots that were untilled (ZT)respectively for 2013 and 2014 cropping seasons. The differences observed in the NFPP of water melon over the period of study could be attributed to the amount of rainfall received over the years.

Table 4: Growth Parameters of Water Melon as affected by different Tillage Method

		2013			2014			Combined Analysis		
S/N	Treatment	Days in 50% germination	Days to 50% Flowering	Days to 50% Maturity	Days to 50% Germination	Days to 50% Flowering	Days t o 50% Maturity	Germination	Flowering	Maturity
1.	ZT	5.0^{d}	8.0^{d}	48.0^{d}	6.0^{d}	10.0^{d}	57.0^{d}	5.5^{c}	9.0^{c}	52.5^{c}
2.	DH	7.0^{c}	22.0^{c}	57.0^{c}	8.0^{c}	24.0^{c}	69.0^{c}	7.5^{b}	23.0^{b}	63.0^{b}
3.	DP	6.0^{c}	20.0^{c}	55.0^{c}	7.0^{c}	21.0^{c}	65.0^{c}	6.5^{b}	20.5^{b}	60.0^{b}
4.	DDH	8.0^{b}	27.0^{b}	65.0^{b}	11.0^{b}	29.0^{b}	76.0^{b}	9.5^{a}	28.0^{b}	70.5^{a}
5.	DDP	7.0^{b}	25.0^{b}	62.0^{b}	9.0^{c}	$27.0^{c.}$	73.0^{c}	8.0^{b}	26.0^{b}	67.5^{b}
6.	DP/DH	12.0^{a}	33.0^{a}	78.0^{a}	14.0^{a}	38.0^{a}	82.0^{a}	13.0^{a}	35.5^{a}	80.0^{a}

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan Multiple Range Test (DMRT)

Table 5: Leaf Area Index (LAI) at 3 to 12 (WAP) in 2013 and 2014

Week	3	6	9	12	3	6	9	12
Treatment			2013				2014	
ZT	3.5^{b}	5.2^{b}	5.6^{b}	6.0^{b}	4.50^{b}	6.30^{c}	6.65^{b}	7.45^{b}
DH	5.6^{b}	8.5^{a}	11.0^{a}	14.5^{a}	6.58^{b}	9.45^{a}	12.50^{a}	16.42^{a}
DP	4.5^{b}	6.5^{b}	8.0^{b}	11.8^{a}	7.35^{b}	9.20^{a}	10.04^{a}	11.25^{a}
DDH	6.2^{a}	7.9^{a}	9.0^{a}	11.4^{a}	8.00^{a}	8.97^{b}	10.40^{a}	12.50^{a}
DDP	5.5^{b}	6.8^{b}	8.8^{a}	9.6^{a}	6.58^{b}	7.97^{b}	9.83^{b}	11.75^{a}
DP/DH	7.9^{a}	9.0^{a}	10.3^{a}	12.8^{a}	8.88^{a}	10.43^{a}	11.40^{a}	13.85^{a}

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan's Multiple Range Test (DMRT)

Table 6: Plant Length (m) for 3 to 12 weeks in 2013 and 2014

	2013				2014				Combined			
WAP	3	6	9	12	3	6	9	12	3	6	9	12
Treatment												
ZT	1.5^{b}	1.9^{b}	2.1^{a}	2.3^{a}	1.6^{b}	2.0^{a}	2.2^{a}	2.3^{a}	1.6^{b}	2.0^{a}	2.2^{a}	2.3^{a}
DH	1.6^{b}	2.1^{a}	2.2^{a}	2.4^{a}	1.7^{b}	2.2^{a}	2.4^{a}	2.5^{a}	1.7^{b}	2.2^{a}	2.3^{a}	2.5^{a}
DP	1.7^{b}	2.2^{a}	2.4^{a}	2.5^{a}	1.8^{b}	2.4^{a}	2.5^{a}	2.6^{a}	1.8^{b}	2.3^{a}	2.5^{a}	2.6^{a}
DDH	2.0^{a}	2.2^{a}	2.4^{a}	2.7^{a}	2.1^{a}	2.6^{a}	2.7^{a}	2.9^{a}	2.1^{a}	2.4^{a}	2.6^{a}	2.8^{a}
DDP	1.9^{a}	2.3^{a}	2.5^{a}	2.8^{a}	2.0^{a}	2.7^{a}	2.8^{a}	3.0^{a}	2.0^{a}	2.5^{a}	2.7^{a}	2.9^{a}
DP/DH	2.2^{a}	2.7^{a}	2.9^{a}	3.0^{a}	2.4^{a}	2.8^{a}	3.0^{a}	3.2^{a}	2.3^{a}	2.8^{a}	3.0^{a}	3.1^{a}

Values followed by the same letter in a column are not statistically different at 5% level using the Duncan Multiple Range Test (DMRT)

Table 7: Number of Fruits per plant (NFPP)

Treatment	2013	2014	Combined
ZT	4^{d}	6^{d}	5.0^{c}
DH	6^{c}	10^{c}	8.0^{b}
DP	4^{c}	11^{c}	7.5^{b}
DDH	10^{c}	15^{b}	12.5^{a}
DDP	11^{b}	21^{b}	16.5^{a}
DP/DH	16^{a}	26^{a}	21.0^{a}

Values followed by the same letter in a column are not statistically different at 5% levels using the Duncan's Multiple Range Test (DMRT).

3.5.2: Fruit length:

Table 8 shows the fruit lengths (FL) of watermelon for the year 2013 and 2014. It could be observed that the different tillage treatments had translated into significant differences on the fruit length. The highest fruit length of 33.4 and 33.8 cm in 2013 and 2014 respectively was obtained from the treatment DP/DH, and the lowest values of FL (20.7 and 26.4 cm) were recorded from the zero tillage (ZT) treatment. The FL of watermelon ranged between 20.7 to 33.4 and 26.4 to 33.8cm in 2013 and 2014 cropping seasons respectively. This could be attributed to the amount of rainfall received and the effect of weather, and variation in seedbed preparation from the different tillage methods

Table 8: Fruit Length (cm)

Treatments	2013	2014	Combined
ZT	20.7^{c}	26.4^{c}	23.6^{c}
DH	21.4^{b}	27.0^{b}	24.2^{b}
DP	23.0^{b}	27.9^{b}	25.5^{b}
DDH	22.5^{a}	29.0^{a}	25.8^{a}
DDP	25.8^{a}	31.2^{a}	28.5^{a}
DP/DH	33.4^{a}	33.8^{a}	33.6^{a}

Values followed by the same letter in a column are not statistically different at 5% levels using the Duncan's Multiple Range Test (DMRT)

3.5.3 Mean Fruit Weight (MFW)

Table 9 shows fruit weight of watermelon for the year 2013 and 2014 cropping seasons. The heaviest watermelon fruit (5.4kg) was obtained from DP/DH treatment, while the lightest fruits (2.5kg) came from the zero tillage (ZT) treatment for year 2013cropping season, but the differences were not statistically different. Similar results were found in the 2014 cropping season. On the average, MFW ranged from 2.6 to 4.4 kg in the decreasing order of ZT<DH<DP<DDH<DDP<DP/DH.

Table 9: Mean Fruit weight (kg)

Cropping seasons	2013	2014	Combined
Treatments			
ZT	2.5^{b}	2.7^{a}	2.6^{a}
DH	2.7^{b}	3.4^{a}	3.1^{a}
DP	2.9^{b}	3.8^{a}	3.4^{a}
DDH	3.3^{b}	4.5^{a}	3.9^{b}
DDP	3.6^{b}	5.2^{a}	4.4^{b}
DP/DH	3.8^{b}	5.4^{a}	4.6^{a}

Values followed by the same letter in a column are not statistically different at 5% levels using the Duncan's Multiple Range Test (DMRT).

3.5.4 Fruit Diameter (MFD)

Table 10 shows mean fruit diameter during the years of study. The Table revealed that longest fruit diameter of 29.0cm was obtained due to DP/DH treatment and the shortest fruit diameter of 20.0cm occurred due to zero tillage (ZT) treatment in the 2014 cropping season. Similar results (26.0 to 18.0) were found in the 2013 season. This could be attributed to the amount of rainfall received and the effect of weather. This is in line with earlier study by Rashidi and Keshavarzpour (2012) who reported the mean fruit diameter of 15.6cm for the DP/DH treatment, but 8.5cm under ZT treatment.

Table 10: Mean Fruit diameter (MFD) (cm)

Cropping seasons	2013	2014	Combined
Treatment			
ZT	18.0^{b}	20.0^{a}	19.0^{a}
DH	19.0^{b}	22.0^{a}	20.5^{b}
DP	21.0^{b}	23.0^{a}	22.0^{a}
DDH	22.0^{b}	25.0^{a}	23.5^{a}
DDP	24.0^{b}	27.0^{a}	25.5^{a}
DP/DH	26.0^{b}	29.0^{a}	27.5^{a}

Values followed by the same letter in a column are not statistically different at 5% levels using the Duncan's Multiple Range Test (DMRT).

3.11 Yield of watermelon (kg/ha)

Table 11 shows the yield of watermelon as affected by the tillage treatments for two cropping seasons. From the table, watermelon yield were found to be in the order of DP/DH>DDP>DDH>DP>DH>ZT. This pattern of yield was the same for the two years study period and is in line with the observations of Rashidi and Keshavarzpour (2012) that worked on the effect of different tillage treatments on the growth and yield of watermelon and soil physical properties. This is expected as the combination of disc ploughing and disc harrowing (DP/DH) treatment produced the best tilth, which resulted in best crop environment, hence the best yield (Dauda, 2011).

Table 11: Yields of watermelon (t/ha) as influenced by the tillage treatments

Cropping seasons	2013	2014	Combined crop yield
Treatment			
ZT	19.5^{b}	22.0^{a}	20.8^{a}
DH	21.0^{b}	23.5^{a}	22.3^{a}
DP	22.8^{b}	24.8^{a}	23.8^{a}
DDH	24.0^{b}	26.0^{a}	25.0^{a}
DDP	25.5^{b}	28.0^{a}	26.8^{a}
DP/DH	26.5^{b}	31.0^{a}	28.8^{a}

Values followed by the same letter in a column are not statistically different at 5% levels using the Duncan's Multiple Range Test (DMRT).

4. Conclusion

The outcome of the two-year experiment showed that the soil properties of a sandy loam soil could be influenced by different tillage methods. The multiple tillage operations transformed soil condition into the best environment for watermelon growth and yield. Evidently the zero tillage system commonly practiced by farmers might have been among the major reasons of poor yield and farmers' economic loss. This gives a room for modifying soil physical properties to suit particular crop requirement using tillage methods. For improved performance, watermelon is thus better grown on well tilled soil that will ensure optimum soil condition for the crop. The study thus discourages zero tillage and inadequate tillage operation for the production of watermelon.

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