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Effects of Different Tillage Methods on the Soil Bulk Density and Growth Parameters of Watermelon (*Citrullus lanatus*)

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Abstract

Research was conducted to determine the effects of different tillage methods on the soil bulk density and growth parameters of Watermelon (*Citrullus lanatus)*. The study was carried out at the Vegetable Research Farm, The Oke – Ogun Polytechnic, Saki; with treatments at three levels of tillage (T0- zero tillage, T1- one pass of moldboard plow and T2- two passes of moldboard plow); all treatments replicated three times and arranged in three blocks in a Completely Randomized Block Design (CRBD). Each plot was (1.2 m x 1.2 m) with 1 m and 1.5 m gap between the plots and blocks. Tillage methods affected the soil bulk density and watermelon growth parameters as shown that one pass of moldboard plow (1.3 gm/cm3) had the greatest mean vine length, stem girth and number of leaves (5.3 cm, 3.1 cm and 13) respectively. Paired t- minitab 17.0 showed that the zero tillage (1.6gm/cm3) and one pass of moldboard plow (1.3 gm/cm3) bulk densities are significantly ($p \leq 0.05$) different, while two passes of moldboard plow (1.5 gm/cm3) and one pass of moldboard plow (1.3 gm/cm3) are statistically ($p \leq 0.05$) the same. The summary of analysis of variance of effects of tillage methods on the watermelon growth parameters, revealed that blocks had no significant ($p \leq 0.05$) effects on all the growth parameters, while tillage had significant ($p \leq 0.05$) effects on the mean vine length, stem girth and leaf area. Least significant ($p \leq 0.05$) different therefore, revealed that one pass of moldboard plow (1.3 gm/cm3) significantly ($p \leq 0.05$) increased the vine length and stem girth than other tillage methods. The study concluded that for a one pass of moldboard plow (1.3 gm/cm3) at 11.5 % moisture content; the growth of watermelon could be enhanced on sandy clay soil, in the derived savannah of Southwest zone of Nigeria.

Keywords: Moisture content; plow; Cucurbitacea; Vegetable; Derived savanna;

Introduction

Watermelon (*Citrullus lanatusThumb*) belongs to the family Cucurbitaceae [1, 2, 3]. Its centre of origin has been traced to both the Kalahari and Sahara deserts in Africa [4] and these areas have been regarded as point of diversification to other parts of the world [1, 2, 3].Sweet, juicy watermelon is actually packed with some of the most important antioxidants in nature. Watermelon is an excellent source of vitamin C and a very good source of vitamin A, notably through its concentration of beta-carotene. Pink watermelon is also a source of the potent carotenoid antioxidant, lycopene. These powerful antioxidants move through the body neutralizing free radicals[5]. 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 savanna region of the Nigeria [6]. Watermelon (Citrullus lanatus) is a relative of melons (Cucumis melo), cantaloupe, honeydew, crenshaw, winter and summer squash (Cucurbita pepo var. melopepo), pumpkin (Cucurbita pepo var. pepo), and cucumbers (Cucumis sativus). Collectively, known as the cucurbits, Watermelon, Citrullus lanatus, is part of the Cucurbitaceae family which includes squash, pumpkins, cucumbers, muskmelons and gourds;it is a vine-like (scrambler and trailer) flowering plant. Watermelon cultivation in the world; 1.8 million hectare (dry land and irrigated) with production of 29.9 million tons [7]. In Nigeria, this fruit crop is mostly cultivated in the northern part because it is a warmth-loving plant and this makes its production seasonal in the southern part of the country [8]. Its global consumption is greater than that of any other cucurbit. According to [9,10], watermelon is the most preferred among five other exotic vegetables (Cucumber, Carrot, Lettuce, Cabbage and Sweet melon) examined in Ibadan Metropolis of Oyo State, Nigeria. Individual plants produce both male and female flowers and fruit size varies from 2 to 14 kg, depending on variety and is thought to have originated in Southern Africa. Today, watermelon is cultivated all over the world on all five continents. Watermelon is frost sensitive and are monoecious (both male and female flowers are produced on the same plant). The flowers remain open for approximately a day and are insect pollinated. Watermelon flowers are yellow, five-petalled flowers about 1 cm in diameter (smaller than some of the other vine fruit). Watermelons are usually eaten as fruit, in fruit salads or as deserts. Optimum germination temperature, growth temperatures at night, day and ripening are 27 – 32 °C, 18 – 20 °C, 24 – 30 °C, 15 - 25°C respectively with night temperature not lower than 24 °C. Watermelons can be grown on a wide range of soil types although sandy soils are preferred. The highest yields

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will generally be produced on well-drained sandy loam soil. Heavy clay soils, soils with obstructed drainage, or very shallow soils should be avoided. Soil pH should be about 5.8-6.2 (H_2O). It is usually recommended to lime soil with pH values below 5.5 (H_2O).

Soil tillage is one of the cultural practices that affect soil physical properties and yield of crops [11,12].reported that among the crop production factors, tillage contributed up to 20 %. Tillage method affects the sustainable use of soil resources through its influence on soil properties, proper tillage can improve soil related constraints, while improper tillage may cause a range of undesirable processes such as destruction of soil structure, accelerated erosion, depletion of organic matter content and fertility destruction of cycles of water, organic carbon and plant nutrients and encourage excessive weed emergence [13,14,15]. The indiscriminate tillage can increased soil erosion, evaporation, decreased permeability, increased runoff and increased soil compaction. In most cases, the performance of crops in conservation plow methods compared with conventional plow methods was similar or was higher [16]. Watermelons grow best on sandy loam soils, with good drainage and a slightly acid pH. When planted in very heavy soils, the plants develop slowly and fruit size and quality are usually inferior. Fine sands produce the highest quality melons when adequate fertilizer and water are provided [17].

The objective of the study was to determine the effects of different tillage methods on the soil bulk density and growth parameters of Watermelon (Citrullus lanatus).

Materials and Method

Site

The study was carried out at the Vegetable Research Farm, The Oke – Ogun Polytechnic, Saki; located within latitude 8.33o N and longitude 3.40o E in the derived savannah zone, South western Nigeria, average humidity, temperature and soil moisture of 66 %, 28 o C and 9.3 % respectively between 10th June and August, 2017. The pattern of rainfall is bimodal, with the average annual rainfall estimated to be about 1100 mm. (The Oke – Ogun Polytechnic WatchDog weather station). The experiment was sited within 1 hectare Agricultural field that has been previously planted with maize and vegetables.

Treatments

Research was conducted with treatments at three levels of tillage (T0- zero tillage, T1-one pass of moldboard plow and T2-two passes of moldboard plow); all treatments replicated three times and arranged three blocks in a Completely Randomized Block Design (CRBD). Each plot was (1.2 m x 1.2 m) with 1 m and 1.5 m gap between the plots/replicates and blocks respectively. The no – tilled or zero tillage was done with contact herbicide (Clearweed @ 3 litres/ha for annual grasses + annual broad leaved weeds), hoe and cutlass to clear the land after three (3) days of application of the herbicide. Pre-cropping chemical analysis of the experimental soil was carried out before land preparation (Table 3). Table 2 indicated the tractor and implement specification used for the experiment, (Table 1)also indicated the composition of the organic fertilizer bought at Agro-allied shop, Saki, Oyo State, Nigeria. Canned seeds of watermelon with inscription: Top Harvest; germination/purification 85 /99 %, treated with Biostim protection, was bought at Agro-allied product shop in Saki, Oyo State, Nigeria,two seeds of watermelon were sown perhole with intra and inter row spacing of 1.2 m x 1.2 m and about 2 cm deep, thinned to one seedling per stand 2 Weeks After Planting (WAP). The fertilizer (250 gm/plot) was applied in two split doses, the first application of organic fertilizer was applied two weeks before planting, and the second dose fertilizer treatments was applied three weeks after planting by side dressing and lightly covered with soil. At four weeks of planting, Kuru (Brand insecticide); Cypermethrin 10 % EC was applied at 650ml/ha.

Table1: Labeled chemical composition of the synthetic organic fertilizer used

Composition	%
Nitrogen	5
Phosphorous	2.5
Potassium	1.5

Soil Analysis and Growth Parameters

Three core samples were taken randomly at the research locations at depth of 15 cm with the aid of 5 cm diameter metal cylinder (core sampler) for routine physical and chemical analysis. The soil samples were air dried, crushed and sieved to pass through 2 mm sieve, and analyzed. The particle size distribution was carried out using the hydrometer method described by as presented by using 0.2 M sodium hydroxide as dispersing agent[18,19]. Undisturbed soil cores were collected by driving with a rubber hammer 5 cm diameter metal cylinder into the soil to the depth specified for each sample. Bulk densities were calculated based on the volumes, calculated from the length and diameter of the section and dry weights of the soil samples. The soil pH was determined using a glass electrode pH meter, that is; soil – water suspension (1:1); organic carbon was determined by the chromic acid digestion method [20]. The total nitrogen concentration was determined by macro-Kjeldahl method and the available P was extracted by Bray -1 method and determined using spectrometer[21,22]. Exchangeable K, Ca, Na, and Mg were extracted with neutral (pH 7) solution of 1N NH4OAc, K and Na were determined using the flame photometer and Mg and Ca by the atomic absorption spectrophotometer. Growth parameters of watermelon were measured from the plots; vine length (cm), stem girth (cm), number of leaves and mean leaf area (cm2) at the end of the experiment (7 weeks). The taller plant from each plot was selected for vine length measurement which was measured from the soil level to tip of the plant with a meter rule. The leaf area (length x width) was also measured by the meter rule, leaf length was measured from the lamina tip to the point of intersection of the lamina and petiole and the width measured from tip to tip between the widest lamina lobes. The number of leaves was simply counted, while the stem girth was measured by measuring the stem close to the ground with vernier caliper.

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Statistical Analysis

Statistical significance of bulk densities generated as a result of different tillage methods was evaluated using Paired t – samples of Minitab 17.0 statistical software package, while data collected from the field on effects of the tillage methods on the growth parameters of Watermelon (Citrullus lanatus)were subjected to Analysis of Variance (ANOVA) and Least Significant Different (LSD) to seperate the means.

Results and Discussion

The properties of the soil used for the experiment (Table 3) indicated a sandy clay soil (sand 67 %, silt 8 % and clay 25 %) and pH of 6.9.The slightly acidity nature of the soil could be as a result of high rainfall in the area which made the soil fragile and susceptible to erosion and leaching [23]. The pH of 6.9, however, was within acceptable range expected for optimum growth of the crop as the pH should not be less than 5.5. The effect of tillage methods (zero – tilled; 1.6 g/cm^3, one pass of moldboard plow; 1.3 g/cm^3 and two passes of moldboard plow; 1.5 g/cm^3) (Table 5 – 8), the zero -tilled bulk density was the highest (1.6 g/cm^3) while the one pass of moldboard plow (1.3 g/cm3) reduce the bulk density and the bulk density increased at two passes of moldboard plow (1.5 g/cm^3). The soil preferred for watermelon was sandy soil, however, the soil type used for this experiment was sandy clay and this could be the reason for the high bulk densities of the different tillage methods. The statistical significant effects of these bulk densities were tested by paired t – samples Minitab 17.0 soft ware package; result showed that the zero and one pass of moldboard plow bulk densities are significantly ($p \leq 0.05$) different, while two passes of moldboard plowand one pass of moldboard plow are statistically ($p \leq 0.05$) the same (Table 4). The tractor and the implements specifications used for this study (Table 2) was not a heavier type according to [24]. Result presented here was also consistent with those obtained by [25] who studied the influence of different tillage systems on bulk density, [26] similarly observed significantly higher bulk density under zero or no tillage cultivation when compared to conventional tillage treatment. This finding was also in agreement with what was reported by [27,28, 29].One of the reasons for increasing the soil bulk density in no till system is this system because of non-use of tillage machines will not also cause any upset. These results are therefore, compatible with findings of [30, 31].

Table 2: Tractor and implement specification

Item	Specification
(a) Disc plough	
Number	3
Dimension	2.2 m
(b) Tractor source of power	Diesel
(c) Weight of tractor	2.4 tons
(d) Number of cylinder	4
(e) Model of tractor	Mahindra 605 D1
(f) Horse power	65

Table 3: The physical and chemical parameters of the soil used for the experiment

Parameter	value
PH (H_2O)	6.9
Sand (%)	67
Clay (%)	25
Silt (%)	8
Texture	Sandy clay
Moisture content at tillage (%)	11.5
Exchangeable bases (mol/kg)	
Ca	38
Mg	2.4
Na	0.1
K	0.7
H+AL	0.1
Exchangeable CEC (C mol/kg)	39
% Base saturation	65.6
Micro nutrient (mg/kg)	
C	4.4
N	1
P	8
Cu	0.6
Mn	11
Fe	15
Zn	2

Table 4:* Paired t – samples Minitab test of effect of different tillage methods on bulk density

Tillage/bulk density	t - value	P- value
aT0 – T1b	5.2	0.04*
aT0 –T2a	0	1.00ns
aT1 – T2a	-3.46	0.07ns

The effect of tillage methods (Table 5) indicated that one pass of moldboard plow (1.3gm/cm^3) had the highest mean vine length (5.3 cm) while the zero tillage(1.6gm/cm^3)had the least (3.5 cm). Tillage systems affected the water melon stem girth (Table 6) as shown that the one pass of moldboard plow(1.3 gm/cm^3) had the greatest girth (3.1 cm) and the least girth (1.3 cm) was obtained as a result of zero tilled (1.6gm/cm^3)effect. Table 7 observed the leaf area; which indicated that two passes of moldboard plow(1.5gm/cm^3)had the largest leaf area (30 cm^2) and the least (22.8 cm^2) was at zero –tilled(1.6gm/cm^3). The highest mean number of leaves (Table 8) was obtained at one pass of moldboard plow (1.3gm/cm^3) plot (13) while zero – tilled (1.6gm/cm^3)plot recorded the least mean number of leaves (9). The summary analysis of variance (Table 9) and LSD (Table 5 – 8) indicated that block significant ($p \leq 0.05$) effectwas not observed on all the growth parameters. Tillage methods as treatment however, had significant ($p \leq 0.05$) effects the vine length, stem girth and

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leaf area except number of leaves where no significant ($p \leq 0.05$) effects of tillage methods was observed. Least significant ($p \leq 0.05$) different of means effects on the vine length, stem girth and leaf area showed that one pass of moldboard plow(1.3gm/cm^3) and two passes of moldboard plow(1.5gm/cm^3)tillage methods were statistically ($p \leq 0.05$) the same, but the zero(1.6gm/cm^3) tillage had negative or reduced significant ($p \leq 0.05$) effects on the vine length. The stem girth of watermelon increased significantly ($p \leq 0.05$) by the one pass of moldboard plow(1.3gm/cm^3) tillage method, however, the two passes of moldboard plow(1.5gm/cm^3) and zero tillage (1.6gm/cm^3) tillage methods had the same statistical ($p \leq 0.05$) effects on the stem girth of watermelon. The two passes of moldboard plow(1.5gm/cm^3)and one pass of moldboard plow(1.3gm/cm^3)had the same statistical ($p \leq 0.05$) effect on the leaf area, but significantly ($p \leq 0.05$) different from the zero (1.6gm/cm^3)tillage method.

[32] Generally, the soil type (sandy clay) and the available moisture content (11.5 %) at tillage could have effects on the bulk densities and this consequently, resulted in lowered vine length, number of leaves and significantly ($p \leq 0.05$) reduced the stem girth on the two passes of moldboard plow (1.5gm/cm^3) when compared with one pass of moldboard plow (1.3gm/cm^3) tillage method, this assertion was supported by.

[11] opined that tillage methods significantly ($p \leq 0.05$) affected crop yield, fruit weight, fruit length and fruit diameter of watermelon, also supported the assertion that zero tillage had the highest bulk density.

[33] also concluded under Rice-Wheat system, that tillage practices influenced soil physical characteristics and crop productivity.

One of the reasons for the low yield in no-tillage treatments than other treatments can be linked to seed germination under zero tillage with high bulk density, thus contributed to slow and reduced growth of the growth parameters(vine length, stem girth, leaf area and number of leaves). This was also consistent with the findings of [34, 35].

Table 5: Effect of different tillage methods on the vine length of water melon (n= 27)

Blocks	zero tillage	one pass plow	two passes plow	Σ	mean
	1.6bd	1.3bd	1.5bd	14.3	4.8a
B1	3.5	5.5	5.3	13.5	4.5a
B2	3.5	5.1	4.9	13.8	4.6a
B3	3.6	5.2	5		
Σ	10.6	15.8	15.2		
mean	3.5b	5.3a	5.1a		

Table 6: Effect of different tillage methods on the stem girth of water melon (n= 27)

Blocks	zero tillage	one pass plow	two passes plow	Σ	mean
	1.6bd	1.3bd	1.5bd	5.9	2.0a
B1	1.2	3.2	1.5	6.6	2.2a
B2	1.4	3	2.2	6.7	2.2a
B3	1.3	3.1	2.3		
Σ	3.9	9.3	6		
mean	1.3b	3.1a	2b		

Table 7: Effect of different tillage methods on the leaf area of water melon (n= 27)

Blocks	zero tillage	one pass plow	two passes plow	Σ	mean
	1.6bd	1.3bd	1.5bd	82.8	27.6a
B1	23.6	30.4	28.8	78.8	26.3a
B2	21.2	27	30.6	85.5	28.5a
B3	23.7	31.1	30.7		
Σ	68.5	88.5	90.1		
mean	22.8b	29.5a	30a		

Table 8: Effect of different tillage methods on the number of leaves of water melon (n= 27)

Replicates	zero tillage	one pass plow	two passes plow	Σ	mean
	1.6bd	1.3bd	1.5bd	35	12a
B1	10	14	11	31	10a
B2	8	10	13	34	11a
B3	9	15	10		
Σ	27	39	34		
mean	9a	13a	11a		

Summary and Conclusion

The effects of tillage methods on the soil bulk density and growth parameters of watermelon at 11.5 % moisture were investigated on a sandy clay soil. Soil dry bulk densities was determined (zero/no – tilled; 1.6 g/cm^3, one pass of moldboard plow; 1.3 g/cm^3 and two passes of moldboard plow; 1.5g/cm3) by the core method and indicated that soil physical property (bulk density) and the growth parameters of watermelon were influenced by the tillage methods.

The result indicated that zero tillage method at 1.6 g/cm^3 bulk density significantly ($p \leq 0.05$) reduced the vine length, stem girth, leaf area, but the reduction in the number of leaves was not significant ($p \leq 0.05$). The one pass of moldboard plow (1.3 g/cm3) tillage method had significant ($p \leq 0.05$) effects on the

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Table 9: Summary of analysis of variance (ANOVA) of effects of different tillage methods on growth parameters of watermelon

Source of variation	vine length		stem girth		leaf area		no. of leaves	
	ms	fcal	ms	fcal	ms	fcal	ms	fcal
Block	0.05	2.5ns	0.06	0.86	3.79	1.82ns	1.44	0.32ns
Tillage	2.7	135*	2.47	35.29*	48.28	23.21*	12.11	2.73ns
Error	0.02		0.07		2.08		4.44	

vine length, stem girth and the leaf area while the two passes of moldboard plow (1.5 g/cm^3) tillage method observed significant ($p \leq 0.05$) effects on leaf area only, but statistically ($p \leq 0.05$) the same with one pass of moldboard plow (1.3 g/cm^3) tillage method.

This study, therefore, concluded that for a tillage method (one pass of moldboard plow) at 11.5 % , 1.3 g/cm3moisture content and bulk density respectively, the growth of watermelon could be enhanced in the derived savannah of Southwest zone of Nigeria as it improved the vine length, stem girth and number of leaves.

Authors' Contributions

K. M Babatunde carried out the field study, soiland crop growth analysis, and statistical analysis and draft the manuscript. J. D Oyedele conceived the study, participated in itsdesign and coordination. K. A Shittu participated in the design of the study, performed statistical analysis and O.A Adekanmbi helped draft the manuscript. All authors read and approved the final manuscript.

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