Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.8, No.4, 2018

Effect of Tillage Methods and Spacing on the Productivity of Waterleaf

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Abstract
An experiment was carried out at the teaching and research farm of Federal University of Technology, Owerri, Nigeria to determine the effect of tillage methods and spacing on the productivity of waterleaf. The treatments consist of three tillage methods (flat, Mound and bed) and three spacing (25x25cm, 30x30cm and 40x40cm). The experiment was a 3x3 factorial arrangement laid out in a randomized complete block design (RCBD) and replicated three times. The results of the experiment indicate improved growth of leaves 40x40cm spacing at 4 and 6WAP. Tillage method using beds and flats produced better and higher yield than mound. However, the waterleaf propagated with 25x25cm spacing produced highest yield (0.6kg/plot) 3000kg ha^{-1} while 40x40cm spacing gave lowest yield (0.323kg/plot) 1610kg^{-1}. From this experiment, the 25x25cm plant spacing is recommended to farmers for waterleaf planting because it maintained soil water because of the close spacing thus improving soil fertility. Farmers are advised to practice this method of vegetable farming which helps to maintain soil fertility for sustainability of vegetable crop production in their area.

Introduction
Waterleaf (*Talinum fruticosum*) is one of the most important vegetable crops of Nigeria and is well adapted to its soil and climatic conditions. Waterleaf ranks first in cultivated area and production among all other vegetables in Nigeria (Ministry of Agriculture, Statistical Yearbook, 2011). The Ministry explained that average national production of waterleaf for the last two years was 4.4 million tones. Although the use of improved varieties and fertilizers has increased waterleaf production to much extent, the full potential of the vegetable crop has not yet been achieved when compared to other progressive countries.

Soil tillage method is one of the very important factors that affect soil physical properties and yield (Rashidi and Hartge 2008). Khurshid and Bremner (2016) reported that among the crop production factors, tillage contributes up to 20%. Tillage method and spacing affects the sustainable use of soil resources through its influence on soil properties (Hammel, 2009). Thus, proper tillage practices can improve soil related constrains, while improper tillage may cause a range of undesirable processes such as destruction of soil structure, accelerated erosion, depletion of organic matter and fertility, and disruption in cycles of water, organic carbon and plant nutrients (Lal, 2011). Also, it is important to point out here that the use of excessive and unnecessary tillage operations is harmful to soil; therefore, there is a significant interest and emphasis on the shift to the conservation tillage and non-tillage method and spacing for the purpose of controlling soil erosion (Iqbal *et al.,* 2015).

Most of the waterleaf production in the eastern region of Nigeria is under conventional tillage (Ministry of Agriculture, 2011). Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content (Rashidi and Hartge 2008). Annual disturbance and pulverization caused by conventional tillage produce a finer and loose soil structure as compared to conservation and non-tillage method and spacing which leave soil intact (Rashidi and Hartge 2008). This difference results in change in number, shape, continuity and size distribution of the soil pores network, which controls the ability of soil to store and transmit air, water and soil nutrients. This also improves porosity and water holding capacity of the soil leading to a favorable environment for crop growth and nutrient use (Khan and Bauder*.,* 2011). On the other hand, conservation tillage method and spacing often result in decreased pore space, increased soil strength (Bauder *et al*., 2011) and stable aggregates (Bauder *et al*., 2011). The soil pores network in conservationally tilled soil is usually more continuous because of earthworms, root channels and vertical cracks (Cannel, 2015). Hence, conservation tillage may reduce disruption of continuous pores. Accordingly, Reddy and Taki (2007) quantified the amount of carbon dioxide (CO_2) released from soil as a result of different tillage method and spacing and they observed 37% higher CO_2 efflux from conventionally tilled soils compared to no-till soils which represents higher carbon sequestration in no-till soils. However, the results of conservation tillage and no-tillage method and spacing are contradictory (Iqbal *et al.*, 2015).

Tillage method and spacing according to Hammel, 2009 affects sustainable use of soil resources through its influence on soil quality. Tillage systems; particularly conventional tillage system, adversely affect soil quality by damaging soil structure, decreasing soil moisture content, increasing soil bulk density and root penetration resistance (Rashidi and Hartge 2008).

Furthermore, continuous cultivation under conventional or intensive tillage leaves soil bare and unprotected, thereby promoting soil structure deterioration and leading to excessive high soil temperature (Derpsch *et al.,* 2009). However, no-tillage system improves the soil's moisture retention, aeration, infiltration and reduces run off and evaporation (Duiker and Myers, 2005). Also, annual disturbance and pulverization caused by conventional tillage produce a finer and loose soil structure as compared to conservation and no-tillage method and spacing which leaves the soil intact (Rashidi and Hartge 2008).

From all the above, it is clear that improper agricultural tillage practices have adverse effects on soil fertility. However, farmers appear to be ignorant in their farming activities on the fertility of the soil as well as the environment. Agriculture is the basis for human survival and therefore, the need to ensure the provision of safe food and environment for the future generation of farmers. Soil is the very resource on which agriculture is based and needs to be protected so as to enable food production to be continuous and beneficial in order to ensure food security for the ever growing world population.

Materials and methods

Experimental Site

The research was conducted between August and September, 2017 at the school of Agriculture and Agricultural Technology (SAAT), teaching and research farm, Federal University of Technology Owerri (FUTO), Nigeria, located between latitude $5^0 24^/$ North and longitude $07^0 02^/$ East with an elevation of 57m above the sea level. It has a bimodal pattern of rainfall with the peaks in July and September and a break in August. It has a temperature 25.5^0C and 31.9^0C for minimum and maximum respectively. It is characterized with annual rainfall of 2500mm with relative humidity between 84-89%.

Experimental Design

A total area of land measuring 7.6 x 26m= 212.8m^2, was cleared using cutlass and spade. The trash was packed away and the sumps were also removed. The field was then mapped out into plots using pegs, 50m measuring tape, ranging poles and rope. The experiment was laid out as a 3x3 factorial fitted into a Randomized Complete Block Design (RCBD), with three replications. The total area was 212.8m^2, each unit or plot was 2 x 1m = 2m^2, distance between plots and blocks were = 1m.

Treatments

Flat A_1= 25 x 25cm, A_2= 30 cm x 30cm and A3= 40 x 40cm
Bed A4= 25 x 25cm, A5= 30 x 30cm and A6= 40 x 40cm
Mound A7= 25 c x 25cm, A8= 30 x 30cm and A9= 40 x 40cm

Planting

Planting of waterleaf using stem cuttings were done on tilled beds after land preparation, and the stem of waterleaf were planted on the beds at a spacing of 25 x 25cm, 30 x 30cm, 40 x 40cm at the rate two (2) stems cuttings per hole. The different spacing had different plant population as 25x25cm had 360,000 stands ha^{-1} 30x30cm had 240,000 ha^{-1} and 40x40cm had 150,000 ha^{-1}.

Data Collection:

The following data were collected at the growing stage of the crop and its harvest respectively.
Emergency count at one (2) week: This was done by counting the number of leaf that emerged and divided by the number of stem planted per hoe in a plot.
Height: This was measured in centimeters (cm) with the help of a measuring ruler from the base to the tip of the last leaf of the selected plant.
Number of leaves per sampled plant: The total number of leaves was counted per plant on five (5) randomly selected plants and the mean was recorded at 2, 4, 6 and 8 weeks after planting.
Percentage sprouting of stem cuttings**:** The percentage sprouting of stem cutting was obtained and the number of days the crop took to sprout was recorded.
Number of stem per plant: This is the number of waterleaf stem and branches in each plot.
Number of leaves per plant: This is the number of waterleaf leaf collected per stand.
Yield/weight: After harvest, the leaves per small bundle per plot was weighed (g) and later converted to kg/ha.

Results and Discussion

Results Table 1 indicate the effect of spacing and tillage on the number of leaves of water leaf at 2, 4 and 6WAP.

The results showed that spacing/tillage and their interaction has no significant difference at 2WAP. Plant spacing was significantly different (P = 0.05) at 4 and 6WAP with the widest spacing (40 x 40cm) producing the highest leave number (64.2) at 6WAP, followed by 30 x 30cm (56.0) and 25 x 25cm (50.7) respectively. This shows that from the experiment lowering plant densities increased the nutrient area per plant which led to increased morphological character expression by the waterleaf vegetable crop.

Table 1: Effect of spacing and tillage on the number of leaves of water leaf at 2, 4 and 6WAP

	Number of Leaves											
	2WAP				4WAP				6WAP			
Spacing cm	Tillage Bed	Flat	Mound	Means	Bed	Flat	Mound	Means	Bed	Flat	Mound	Means
25 x 25	26.5	19.1	17.4	21.0	46.7	50.3	56.5	51.2	43.3	5.53	53.3	50.7
30 x 30	41.1	33.1	39.0	37.7	57.5	39.4	39.3	42.1	60.0	48.7	59.3	56.0
40 x 40	17.2	99.1	49.0	55.1	67.0	24.9	22.0	39.3	69.3	57.3	66.0	64.2
Mean	28.3	50.4	35.2		53.7	38.2	39.3		57.5	53.8	59.5	
Spacing $LSD_{0.05}$				NS				7.94				0.952
Tillage $LSD_{0.05}$				NS				NS				NS
Spacing x Tillage				NS				NS				NS

The effect of spacing and tillage practices on plant height at 2,4 and 6WAP are shown in Table 2. Spacing produced significant effect (P=0.05)) at 2WAP with the tallest height (14.84) produced by (25 x 25cm). Tillage had significant effect (p = 0.05) at 4WAP with tallest plant (21.6cm) got from bed, followed by mound (12.8) and flat 12.2cm respectively. This shows from the findings that the tallest plant height observed in narrow spacing was due to greater competition for air space and light and some mineral resources thereby forcing the plants to grow taller. For the tillage this agreed with Lal (2011) that tillage optimizes soil and environmental condition for growth.

Table 2: Effect of Spacing & Tillage Method on Plant Height of Water Leaf at 2, 4, and 6WAP

	Plant Height											
	2WAP				4WAP				6WAP			
Spacing cm	Tillage Bed	Flat	Mound	Means	Bed	Flat	Mound	Means	Bed	Flat	Mound	Means
25 x 25	15.59	13.95	14.99	14.84	12.9	17.1	20.7	16.9	88.8	94.7	10.57	9.71
30 x 30	15.59	16.13	13.15	14.06	32.6	14.9	11.3	19.6	10.4	90.7	86.0	9.36
40 x 40	5.91	11.93	11.24	9.96	19.3	4.7	6.5	10.2	11.13	12.07	99.3	14.4
Mean	9.03	10.67	9.50		21.6	12.2	12.8		10.11	10.20	95.0	
Spacing $LSD_{0.05}$				5.064				NS				NS
Tillage $LSD_{0.05}$				NS				7.84				NS
Spacing x Tillage				NS				13.55				NS

Table 3 shows the effect of spacing and tillage method on plant girth of water leaf at 2, 4 and 6WAP. The results indicates that spacing had significant difference (P=0.05) at 2 and 4WAP. Higher spacing increased the stem girth and the highest mean girth was produced at 4WAP from 40 x 40cm (4.70cm) followed by 30 x 30cm (4.65) and 25 x 25cm (2.70cm). Tillage method had significant effect at 6WAP with mound having highest girth (0.716). It was observed that the older the waterleaf plant, the lesser the stem in girth. This could be observed at 6WAP. The result however showed that increased spacing increases the stem diameter linearly and their girth decreases with age (Table 3) on tillage , at 2WAP, there were no difference among the bed, flat and mound, whereas at 4WAP, bed had higher plant heights (21.6cm) and was taller than the plant in flat (12.2cm) and mound 12.8cm respectively. However, at 6WAP, there were no observable differences among the plants. This could be attributed to the period of flowering when the plant stopped growing but produced flowers and fruits and growth reduced due to too much branching by the waterleaf vegetable crop.

Table 3: Effect of spacing and tillage method of plant girth of water leaf at 2, 4 and 6WAP

			Girth									
	2WAP				4WAP				6WAP			
Spacing cm	Tillage Bed	Flat	Mound	Means	Bed	Flat	Mound	Means	Bed	Flat	Mound	Means
25 x 25	1.53	1.49	1.42	1.48	1.09	1.89	4.12	2.70	0.40	0.453	0.60	0.484
30 x 30	3.91	4.11	3.32	3.78	5.49	3.11	4.30	4.65	0.493	0.407	0.707	0.536
40 x 40	2.18	2.36	2.73	2.42	5.77	4.77	3.17	4.70	0.387	0.607	0.840	0.611
Mean	2.54	2.65	2.49		3.25	3.59	3.56		0.427	0.489	0.716	
Spacing $LSD_{0.05}$				0.758				1.101				NS
Tillage $LSD_{0.05}$				NS				NS				0.1793
Spacing x Tillage				NS				1.907				NS

Table 4: Effect of Spacing and Tillage methods on the Yield (kg/plot) of Water leaf

Spacing cm	**Tillage Bed**	**Flat**	**Round**	**Means**
25 x 25	0.533	0.900	0.367	0.600
30 x 30	0.700	0.681	0.184	0.577
40 x 40	0.412	0.388	0.200	0.323
Mean	0.548	0.646	0.250	
Spacing $LSD_{0.05}$				0.2587
Tillage $LSD_{0.05}$				NS
Spacing x Tillage				0.4480

Table 4 presents the effect of spacing and tillage method on the yield of water leaf. From the results, the highest yield was produced from the lowest spacing 25 x 25cm (0.6kg/plot) i.e 3000kg ha^{-1} followed by 30 x 30cm (0.522kg/plot) i.e2610kg ha^{-1} and 40 x 40cm (0.323kg/plot). i.e 1610kg ha^{-1}. This result clearly indicates that increasing plant density through closer spacing increased yield per unit land area but reduced yield per individual plant. This increase in yield from close spacing could be attributed to less competition from weed as their spacing smother weeds. Also, it is evident from this research that fresh weight yield of waterleaf is highest in closer spacing within row than in wider spacing within and or along the rows. Therefore practices that sustain soil fertility must be advocated to help farmer sustain their soils for future vegetable crop production.

On the other hand, when tillage practices is considered, it is better planting on flat or bed as they gave the highest yields of 0.646kg/plot (3230kg ha^{-1}) and 0.548kg/plot (2740kg ha^{-1}) better than mound which produced 0.250kg/plot (1250kg ha^{-1}).

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