JOURNAL OF HORTICULTURE AND POSTHARVEST RESEARCH
2021, VOL. 4(2), 177-188

Journal of Horticulture and Postharvest Research

Journal homepage: www.jhpr.birjand.ac.ir

University of Birjand

Effects of different tillage systems on the emergence of okra in Wukari, Taraba State, Nigeria

Ezekiel Ambo Mamai[1*], Tanko Bako[2] and Danasabe Dinvala P.[1]

1, *Department of Soil Science and Land Resource Management, Federal University, Wukari, Nigeria*
2, *Department of Agricultural and Bio-Resources Engineering, Taraba State University, Jalingo, Nigeria*

ARTICLE INFO

Original Article

Article history:
Received 2 June 2020
Revised 30 August 2020
Accepted 2 September 2020
Available online 6 November 2020

Keywords:
Germination
Operations
Properties
Seeds
Soil

DOI: 10.22077/jhpr.2020.3425.1147
P-ISSN: 2588-4883
E-ISSN: 2588-6169

***Corresponding author:**
Department of Soil Science and Land Resource Management, Federal University, Wukari, Nigeria.
Email: mamaiezekiel@yahoo.com

ABSTRACT

Purpose: This study aimed to investigate the effect of different tillage methods on the emergence of okra. **Research method:** The study was carried out at the teaching and research farm of the Federal University, Wukari, Taraba State in July 2018. Tillage treatments in the study were no-tillage, disc plowing, and disc plowing followed by disc harrowing, arranged in a Randomized Complete Block Design, replicated three times. Each plot was (4.0 m × 3.0 m) with a 1.5 m gaps between the plots/replicates and blocks. **Findings:** The results indicated that the tillage methods had no significant ($P \leq 0.05$) effects on the emergence of okra seeds. The maximum values of the number of emerged seeds (52 seeds), percentage emergence (92.86%), emergence rate (16.30%.day^{-1}) and seed vigor index (40.08 seeds.day^{-1}) were obtained in the plowing and harrowing method. In comparison, the minimum values of the number of emerged seeds (45 seeds), percentage emergence (80.36%), emergence rate (16.13%.day^{-1}) and seed vigor index (32.77 seeds.day^{-1}) were obtained in the no-tillage method. The plowing and harrowing approach had the lowest values of mean seed emergence time (6.13days) and seedling mortality rate (5.77%) while the no-tillage process had the highest amounts of mean seed emergence time (6.20days) and seedling mortality rate (13.33%). **Limitations:** There were no limitations to the report. **Originality/Value:** The results suggest the plowing and harrowing method may be utilized as a more appropriate and profitable tillage method in improving soil physical properties and seed emergence of okra.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a popular vegetable crop of the tropical countries and a good source of carbohydrate, protein, dietary fiber, minerals, and vitamins. Okra farming is quite lucrative due to the popular demand for this vegetable in Nigeria. The crop can be cultivated at the backyard, and the cultivation of the plant is not capital intensive, and is very lucrative. There is a readily available market for both the pods and seeds. Tillage is one of the essential activities in the crop production system that optimizes the conditions of the soil bed environment for seed germination, seedling establishment, and crop growth. Among the crop production factors, tillage contributes up to 20% of total production cost (Khurshid et al., 2006). The yield increase was correlated with improvement in an increase in water contents in the soil due to reduced evaporation. The most effective way to reduce soil compaction is tillage. Subsoil compaction may reduce the availability and uptake of water and plant nutrients, thereby lowering crop yields. Among the management options for remediation of subsoil compaction are deep tillage and selection of crop rotations with deep-rooted crops. Deep tillage breaks up high-density soil layer, improves water infiltration and movement in the soil, enhances root growth and development, and increases crop production potential (Motavalli et al., 2003). The tillage method affects the sustainable use of soil resources through its influence on soil properties (Olaoye, 2002). The choices relating to tillage methods are strongly affected by the other components of the cropping system. Thus, the selection of tillage method is crucial for cultivation. The proper use of tillage can improve soil-related constraints. In contrast, 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 nutrient (Wlaiwan & Jayasuriya, 2013). The use of excessive and unnecessary tillage operations is often harmful to the soil. Therefore, currently, there is a significant interest and emphasis on the shift from conventional tillage methods to the conservation and no-tillage methods to control erosion process (Iqbal et al., 2005).

Tillage practice suppresses weeds, controls soil erosion, maintains adequate soil moisture, and creates an ideal seedbed condition for seedling emergence and development (Licht & Al-Kaisi, 2005). Tillage practice also affects plant root growth (Lampurlanes et al., 2001), grain yield, and the incomes of farmers (Cavalaris & Gemtos, 2004). Motavalli et al. (2003) stated that deep tillage improved the root length, root proliferation, and nitrogen recovery efficiency; that lower nitrogen recovery efficiency was recorded in the no-tilled soil treatment than the compacted in sub-soiling procedures. However, the choice of the most appropriate type of tillage depends on physical factors, such as soil properties, rainfall regime, climate, drainage conditions, rooting depth, soil compaction, erosion hazards, cropping systems, and social-economic factors, including farm size, availability of inputs, and marketing and credit facilities. Researchers have emphasized the benefits of conservation agriculture and adoption at the farm level, which is associated with lower labor and farm power inputs, more stable yields, and improved soil nutrient exchange capacity. Use of correct tillage methods may contribute to higher profits, crop yields, soil improvement and protection, weed control, and optimum use of water resources since tillage has a direct impact on soil and water quality (Lampurlanes & Cantero-Martinez, 2003). Therefore, site-specific knowledge of prevailing tillage systems is required for planning and evaluating the best alternative strategies to increase crop productivity. At this time, a wide range of tillage methods is being used in Wukari without assessing their effects on soil physical properties and crop growth. Therefore, the present investigation was to determine the impact of different tillage methods on okra seed emergence of Federal University, Wukari research farm.

The standard tillage practices in farmlands of Nigeria are mostly with disc plows and harrows. Three or four-discs plow systems at primary tillage and seven-disc harrow system at secondary tillage is the standard practice. In primary tillage, plowing is done one to two times up to the depth of 15-20 cm, followed by harrowing as secondary tillage. Under certain circumstances, this could result in excessive compaction of soil at the depth range of 30 to 50 cm, and resulting in lower yields (Sauwa et al., 2013). Due to handling difficulties, most farmers burn the residues of the previous crop on the field after harvesting or before land preparation. These practices need thorough investigations incorporating all the constraints in the operations. Okra farming requires proper planning, commitment, dedication, and good cultural practices to generate a good yield. The seeds of okra are typically sown at depths of 5-6 cm; hence, the germinating seeds are likely to encounter mechanical resistance when growing to the soil surface (Sauwa et al., 2013). Therefore, soil physical properties such as bulk density, moisture content, and soil strength play a significant role in germination and emergence of a seedling. Since germination and seedling development are the pioneer steps for crop growth, development, and yield, the study of germination indices and seedling quality is highly indicative of the subsequent performance of seed throughout the growing period (Khajeh-Hosseini et al., 2009). Under this perspective, the present experiment was undertaken to investigate the effects of different tillage systems on germination indices of okra as a possible quick and reliable test to access the seedling quality and yield. This study will help to find out the suitable tillage type to be employed for okra cultivation.

The objectives of the study were;

i. To determine the effects of tillage on some soil physical properties,
ii. To assess the impact of tillage on okra emergence,
iii. To establish the most suitable tillage system for okra production.

MATERIALS AND METHODS

Study site

The Federal University Wukari Research Farm is located in Wukari, Taraba State, Nigeria. Wukari Local Government lies between latitude 7º52'19" North of the equator and longitude 9º47'33" East of Greenwich Meridian and covers some 4308 square kilometers of area. The statistics at the climatology station showed average annual rainfall of 1300 mm from the year 2000 to 2009 and the average temperature of 28ºC. Rainfall distribution was unimodal, with much of the rain falling between May and October. The wettest months were August and September. The rainy season was followed by a long dry season. During this period, the area comes under the strong influence of the harmattans (winds that originate in the Sahara and blow across the Sahel region) with humidity as low as 10 to 20% during the dry season. The humidity was very high in the wet season, about 80% in August. The temperature characteristics were typical of the West African savannah climate, which was high throughout the year because of high radiation, which was relatively evenly distributed throughout the year with the maximum temperature reaching 39°C, particularly in April and the minimum temperature as low as 18°C between December and January. Agriculture is the most important economic activity in the area, employing more than 90% of the labor force. Most of the farmers are subsistence-oriented. The standard tillage practices in the soils include animal tractions using ox-drawn plow and tractor mounted plows and harrows. The typical crop grown is rice, corn, yam, and vegetables (okra, onions, pepper, and greens).

Description of tractor and machinery used

A new Holland tractor number TT75 was used to pull the field equipment during operations. Specifications of the tractor are Gross weight: 2200 kg; Overall width: 1651 mm; Overall length: 3542 mm and Ground clearance: 338 mm. Disc plow and disc harrow were used for the experiment. The plow consists of three (3) plane concave discs with a spacing of 680 mm. The disc diameter and plow width are 660 mm and 1900 mm, respectively. The harrow consists of eighteen (18) gang plane concave and notched concave discs spaced 225 mm apart. The disc diameter and harrow width are 560 mm and 2200 mm, respectively. The tractor was used for both the plowing and harrowing operations on the experimental plot at the tractor speed of 3 km.hr^{-1}.

Land preparation and planting

The research was conducted with treatments at three levels of tillage (T0- no-tillage, T1- plow and T2- plow plus harrow), arranged in a Randomized Complete Block Design (RCBD), replicated three times. Each plot was (4.0 m × 3.0 m), with a 1.5 m gap between the plots/replicates and blocks. The no-tilled or zero tillage was done with a contact herbicide (Clearweed at 3 Liters.ha^{-1} for annual grasses and annual broad-leaved weeds), hoe and cutlass were used to clear the land after three (3) days of application of the herbicide. Pre-cropping analysis of the experimental soil was carried out before land preparation. The tillage operations were carried out using a new Holland tractor number TT75. Plowing was done with a 3-disc plow while harrowing was done with an offset harrow. For each trial, okra seeds (LD88-1 variety) obtained from Taraba State Agricultural Development Program (TADP), Wukari were planted at a depth of 5 cm, the spacing of 60 cm by 30 cm and seed rate of two (2) seeds per stand in four (4) rows of seven (7) stands making a total of fifty-six (56) seeds per plot.

Sample collection

The soil used for this study was collected with hand auger at the Teaching and Research Farm, Federal University, Wukari. The samples were collected at soil depths of 0-5 cm, 5-10 cm, and 10-15 cm.

Determination of soil physical properties

Soil moisture content

Three soil samples were taken at random locations in each plot from the 0-5 cm, 5-10 cm, and 10-15 cm soil layers with a soil core sampler 5 cm long and 5 cm in diameter. Samples were oven-dried at 105°C for 24 hours to determine the soil moisture content gravimetrically. The gravimetric moisture content was calculated as the mass of moisture in the soil sample divided by the weight of the dry soil multiplied by 100 (Aikins & Afuakwa, 2012).

$$\text{Moisture content (\%)} = \frac{(\text{Wet soil weight}) - (\text{Oven-dried soil weight})}{(\text{Oven-dried soil weight})} \times 100 \quad (1)$$

Soil dry bulk density

Soil dry bulk density in the 0-5 cm, 5-10 cm, and 10-15 cm layers were determined using the core method. Three soil samples were randomly taken per plot using a stainless steel core sampler of dimension 5 cm diameter by 5 cm height. The collected soil cores were trimmed to the exact volume of the cylinder and oven-dried at 105^{o}C for 24 hours. Precautions were taken to avoid compaction inside the core sampler. Dry bulk density was determined from the ratio of the mass of dry soil per unit volume of soil cores (Aikins & Afuakwa, 2012).

$$\text{Bulk density} = \frac{\text{Mass of oven-dried soil (g)}}{\text{Total volume of soil (cm}^3)} \quad (\text{g.cm}^{-3}) \tag{2}$$

Total porosity

The total porosity of the soil in the 0-5 cm, 5-10 cm, and 10-15 cm layers were calculated from the values of the dry bulk density and an assumed particle density of 2.65 g.cm^{-3} using the following Equation (Aikins & Afuakwa, 2012).

$$\text{Porosity} = \left(1 - \frac{\text{Bulk density}}{\text{Particle density}}\right) \times 100 \quad (\%) \tag{3}$$

Soil penetration resistance

Soil penetration resistance is a measure of the soil strength and an indicator of how easily roots can penetrate the soil. Soil strength (N.cm^{-2}) was determined by using a handheld digital penetrometer (D 1558-84 ASTM standard of needle head 0.6 cm) in each treatment at 0-5 cm, 5-10 cm, and 10-15 cm soil depth. Cone base area of 1 cm^2 was used for taking a penetrometer reading in each plot (Sauwa et al., 2013).

Germination study

Four (4) days after planting (DAP), the okra seeds started germinating. Seed germination was recorded regularly until completion of the process at eight (8) days after planting (DAP). At the end of the germination study, various germination indices such as percentage emergence, mean emergence time, emergence rate, and seed vigor index were calculated.

Determination of percentage emergence

Germination count was taken four (4) days after planting (DAP). Seedling emergence was determined by counting the emerged seedling per plot. The sprouted seedlings were counted on each sub-plot and recorded separately, daily, cumulatively. Plant populations were obtained at different phonological stages to evaluate the treatment effect. Emergence percentage or germination percentage (PE) is the relationship among the number of germinated seeds that had all their essential structures and the number of planted seeds. The number of sprouted seedlings for each day was used to determine the percentage of sprouted seedlings for the entire sub-plots. The percentage of emerged seedlings (PE) was calculated for each tillage practice using Equation 4 (Juan et al., 2019).

$$\text{PE} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds planted}} \times 100\% \quad (\%) \tag{4}$$

Seedling mortality rate

Mortality rate (MR) is the percent of the seedlings that germinate but do not survive the seedling stage. It is the ratio of the number of dead seedlings to the number of germinated seeds. The seedling mortality rate was determined from Equation 5.

$$\text{MR} = \frac{\text{Number of dead seedlings}}{\text{Number of germinated seeds}} \times 100\% \quad (\%) \tag{5}$$

Determination of mean emergence time

Mean germination or emergence time (MGT or MET) is a measure of the speed of germination or emergence (Kader, 2005). Mean germination time (MGT), a speed index as quicker germination corresponds to lower values of MGT. The mean germination or emergence time (in days) was determined from Equation 6 (Christos et al., 2019).

$$\text{MGT} = \frac{G_1N_1+G_2N_2+\cdots+G_nN_n}{G_1+G_2+\cdots+G_n} \quad \text{(days)} \tag{6}$$

Where; G_1, G_2,..., G_n = the number of seedlings emerged on the day of observation and N_1, N_2,..., N_n = number of days counted since the day of sowing until the day of observation.

Determination of emergence rate

In agriculture and gardening, the emergence rate (ER) measured in $\%.day^{-1}$ describes how many seeds of a particular plant species, variety, or seed-lot are likely to germinate over a given period. The germination rate provides a measure of the time course of seed germination. The germination rate is useful for calculating the seed requirements for a given area or desired number of plants. For seed physiologists and seed scientists, "germination rate" is the reciprocal of time taken for the process of germination to complete starting from the time of sowing. The emergence rate (also known as germination speed) was determined from Equation 7.

$$\text{ER} = \frac{G_1+G_2+\cdots+G_n}{G_1N_1+G_2N_2+\cdots+G_nN_n} \times 100 \quad (\%.\text{day}^{-1}) \tag{7}$$

Determination of seed vigor index

The seed vigor index (SVI) measured in the number of seeds per day was calculated using Equation 8 (Agrawal, 1999).

$$\text{SVI} = \frac{G_1}{N_1} + \frac{G_2}{N_2} + \cdots + \frac{G_n}{N_n} \quad (\text{seeds.day}^{-1}) \tag{8}$$

Statistical analysis

The data were statistically analyzed using analysis of variance technique appropriate for randomized complete block design, and means were compared using the F-LSD test at 0.05 level of probability. Two statistical packages, SPSS 16 and mini-tab 20 for windows, were used for the statistical analysis.

RESULTS AND DISCUSSIONS

Effects of tillage practices on soil physical properties

The physical properties of soils of the study sites are shown in Table 1.

Soil moisture content

Soil moisture is the source of water for plant use particularly in rain-fed agriculture. Soil moisture is highly critical in ensuring excellent and uniform seed germination and seedling emergence, crop growth, and yield (Aikins & Afuakwa, 2012). Table 1 depicts the mean soil moisture content values obtained under the different tillage practices in the 0-5 cm, 5-10 cm, and 10-15 cm soil layers. At all depths, plots with disc plowing and harrowing treatment had the highest moisture content while the plots treated with no-tillage had the lowest moisture content. Moisture content increased with the soil depth for all the procedures, while the moisture content decreased with the increasing degree of tillage. This result is similar to that of Aikins and Afuakwa (2012) who reported higher soil moisture content in disc plowing followed by disc harrowing plots in comparison with those of disc plowing only and no-tillage treatments for sandy loam soil under cowpea (*Vigna unguiculata* (L) Walp) in Kumasi located in the semi-deciduous agro-ecological zone of Ghana. In contrast, Ojeniyi and

Adekayode (1999) and Olaoye (2002) found higher soil moisture content in no-tillage plots compared with that of disc plowed followed by disc harrowed plots.

Soil dry bulk density

The bulk density of soil indicates the strength of the soil and, thus, resistance to tillage implements or plants as they penetrate the soil. Soils with a higher proportion of pores to solids have lower bulk densities than those that are compact and have fewer pores. Bulk densities over 1600 kg m^{-3} can restrict root growth and result in low levels of water movement into and within the soil (Brady & Weil, 1999). Table 1 shows the values of soil dry bulk density. It was observed that the bulk density decreased with an increasing degree of tillage. The no-tillage treatment recorded the highest dry bulk density, which is significantly higher than that of the disc plowing and harrowing treatment, which produced the lowest dry bulk density for all the 0-5 cm, 5-10 cm, and 10-15 cm soil depths. It was also observed from the result that bulk density values increased with soil depth in all tillage treatments. The result is in line with the findings of Rashidi and Keshavarzpour (2008) that conducted a two-year field experiment to investigate the effect of different tillage methods on soil physical properties and crop yield of melon and reported that different tillage treatments significantly affected soil bulk density during both the years of study with highest soil bulk density of 1.52 g cm^{-3} obtained for the no-tillage treatment and lowest soil bulk density of 1.41 g cm^{-3} for the conventional tillage treatment. The higher values of the soil dry bulk density obtained on no-tillage plots could be attributed to the fact that the soils in no-tillage plots were not disturbed.

Soil porosity

The mean total porosity obtained in the 0-5 cm, 5-10 cm, and 10-15 cm soil layers under the different tillage treatments are presented in Table 1. In all the 0-5 cm, 5-10 cm, and 10-15 cm soil layers, the disc plowing followed by disc harrowing treatment produced the highest total porosity. In contrast, the no-tillage treatment gave the lowest total porosity. Elder and Lal (2008) also reported higher total porosity in the tilled plots than the no-tillage schemes for organic soils of north-central Ohio.

Table 1. Effects of tillage practices on soil physical properties

Soil physical properties	Soil depth (cm)	Tillage types		
		T0-No-tilage	T1-pow	T2-plow and harrow
	0-5	10.69	11.15	11.29
Moisture content (%)	5-10	11.20	11.72	12.69
	10-15	11.83	11.91	14.88
Mean		11.24	11.59	12.95
	0-5	1.85	1.79	1.80
Dry bulk density ($kg.m^{-3}$)	5-10	1.92	1.87	1.85
	10-15	1.94	1.95	1.90
Mean		1.90	1.87	1.85
	0-5	30.19	32.45	32.08
Total porosity (%)	5-10	27.55	29.43	30.19
	10-15	26.79	26.42	28.30
Mean		28.18	29.43	30.19
	0-5	566	265	116
Penetration resistance ($k.Pa^{-1}$)	5-10	588	290	124
	10-15	625	309	129
Mean		593	288	123

Soil penetration resistance

The result of soil penetration resistance (Cone index) at a soil depth ranges of 0-5 cm, 5-10 cm, and 10-15 cm is shown in Table 1. It was observed that the penetration resistance generally decreased with an increasing degree of tillage. Penetration resistance across the three soil depths considered was consistently highest on no-tillage treatment and lowest on disc plowing and harrowing treatment. This agrees with Aikins and Afuakwa (2012) that conducted a field study during the 2009 and 2010 major crop growing seasons under rain-fed conditions on sandy loam soil (Ferric Acrisol) to compare the effect of different tillage practices on some selected soil physical properties under *Asontem* cowpea variety and reported that among the tillage practices, soil penetration resistance was significantly higher under no-tillage treatment as compared with that in the tilled soil treatments. It was also observed from the result that penetration resistance increased with increase in soil depth for all the tillage treatments. Kasap and Coskun (2006) found that penetrometer resistances of soil for different tillage systems increased with soil depth. Osunbitan et al. (2005) reported that the penetration resistance of the soil generally increased with increasing depth for all treatments. The researchers reported a reduction in soil penetration resistances with the intensity of soil manipulation during tillage. The lower penetration resistance obtained on disc plowing and harrowing enhanced better plant root development and nutrient absorption within the soil, which in turn, enhanced better plant growth when compared to untilled plots.

Tillage effect on the emergence of okra

Total okra emergence

The plant population was obtained at different phonological stages to evaluate the treatment effect. Table 2 shows the number of emerged seeds for various tillage operations, while Table 3 is the analysis of variance (ANOVA) of the effects of tillage systems on the number of emerged seeds. The emergence started four days after planting (4 DAP) and stopped eight days after planting (8 DAP). The results showed that the number of emerged seeds increases with an increased level of tillage. The mean values of the experimental results showed that the final numbers of emerged seeds are 45 for no-tillage operations, 49 for plowing operations, and 52 for plowing and harrowing operations. The total numbers of dead seedlings are 6 for no-tillage operations, 5 for plowing operations, and 3 for plowing and harrowing operations. The results of the analysis of variance (ANOVA) of the effects of tillage systems on number of emerged seeds showed that the number of emerged seeds obtained for various tillage operations was not significantly different at $p \leq 0.05$. The results tallied with the findings of Rashidi and Keshavarzpour (2008) that conducted a two-year field experiment to investigate the effect of different tillage methods on soil physical properties and crop yield of melon and reported a non-significant effect of different tillage treatments on the number of plants per hectare at $P \leq 0.05$ during the study years. Tillage treatments in the study were moldboard plow plus two passes of disk harrow as conventional tillage (CT), two passes of disk harrow as reduced tillage (RT), and one pass of disk harrow as minimum tillage (MT) and no-tillage (NT) as direct drilling method. The maximum value of the number of plants per hectare (6360) was obtained in the case of conventional tillage (CT) treatment while the minimum value of the number of plants per hectare (5910) was obtained in case of no-tillage (NT) treatment. Therefore, moldboard plow followed by two passes of disk harrow was found to be more appropriate and profitable tillage method in improving soil physical properties and crop yield of melon due to reduced soil compaction, increased soil moisture content, enhanced seed-soil contact and suppressing weed growth (Rashidi & Keshavarzpour, 2008).

Table 2. Numbers of emerged seeds for various tillage operations

Tillage operations	Number of sprouted seedlings.days^{-1}					Number of dead seedlings
	4 DAP	5 DAP	6 DAP	7 DAP	8 DAP	
No-tillage (T0)	30	35	39	43	45^{a}	6
Plowing (T1)	34	38	43	48	49^{a}	5
Plowing and harrowing (T2)	40	43	47	50	52^{a}	3

Table 3. Analysis of variance (ANOVA) of the effects of tillage systems on number of emerged seeds

Sources	DF	SS	MS	F-cal	F-Tab	Sig.
Tillage types	2	160.000	80.000	2.344^{ns}	3.885	0.138
Error	12	409.600	34.133			
Total	14	569.600				

ns - Not significant at $p \leq 0.05$.

Table 4. Percentage of emerged seeds for various tillage operations

Tillage operations	Percentage of sprouted seedlings/days (%)				
	4 DAP	5 DAP	6 DAP	7 DAP	8 DAP
No-tillage (T0)	53.57	62.50	69.64	76.79	80.36^{a}
Plowing (T1)	60.71	67.86	76.79	85.71	87.50^{a}
Plowing and harrowing (T2)	71.43	76.79	83.93	89.29	92.86^{a}

Table 5. Analysis of variance (ANOVA) of the effects of tillage systems on percentage of emerged seeds

Sources	DF	SS	MS	F-cal	F-Tab	Sig.
Tillage types	2	510.367	255.184	2.344^{ns}	3.885	0.138
Error	12	1306.335	108.861			
Total	14	1816.702				

ns - Not significant at $p \leq 0.05$

Table 6. Mean emergence time, emergence rate, seed vigor index and mortality rate for various tillage operations

Tillage operations	Germination parameters			
	Mean emergence time (days)	Emergence rate (%.day^{-1})	Seed vigor index (seeds.day^{-1})	Mortality rate (%)
No-tillage (T0)	6.20	16.13	32.77	13.33
Plowing (T1)	6.19	16.16	36.25	10.20
Plowing and harrowing (T2)	6.13	16.30	40.08	5.77

Percentage emergence

The data on the emergence percentage are presented in Table 4, while the analysis of variance (ANOVA) of the effects of tillage systems on emergence percentage is presented in Table 5. The results showed that the percentage of emerged seeds increased with an increased level of tillage. According to the mean values of the experimental results, the maximum final emergence percentage of 92.86% was recorded in the plot with plowing and harrowing operations followed by 87.50% final emergence percentage in the plot with plowing operations while minimum final emergence percentage of 80.36% was recorded in the plot with no-tillage operations. The results of the analysis of variance (ANOVA) of the effects of tillage systems on the percentage of emerged seeds showed that the percentage of emerged seeds obtained for various tillage operations were not significantly different at $p \leq 0.05$. This work is in agreement Mohammed and Umogbai (2014) who conducted an experiment to determine the effects of different levels of soil tillage on germination rate and vegetation of maize crop of Benue River flood plains in Makurdi zone and stated that tilled soils are far better for seed germination than untilled soils. No-tillage compared to other types of tillage, had the potential of reducing the free flow of air and water into and within the soil profile (Nkakini et al., 2008). This affected crop emergence.

Mean emergence time, emergence rate, seed vigor index and mortality rate

The results showed that the mean emergence time decreased with an increased level of tillage (Table 6). The mean emergence times were 6.20 days for no-tillage operations, 6.19 days for plowing operations, and 6.13 days for plowing and harrowing operations. The result shows that the emergence rate, seed vigor index, and mortality rate increase with an increased level of tillage. The emergence rate of 16.13 $\%.day^{-1}$ was obtained for no-tillage operations, 16.16 $\%.day^{-1}$ was obtained for plowing operations, and 16.30 $\%.day^{-1}$ was obtained for plowing and harrowing operations. The no-tillage operations had seed vigor index of 32.77 $seeds.day^{-1}$, plowing operations had seed vigor index of 36.25 $seeds.day^{-1}$ while plowing and harrowing operations had seed vigor index of 40.08 $seeds.day^{-1}$. It was found that a maximum mortality rate of 13.33% was recorded in the plot with no-tillage operations followed by a 10.20% mortality rate in the plot with plowing operations while minimum mortality rate of 5.77% was recorded in the plot with plowing and harrowing operations. The lowest mortality rate of seedlings obtained for plowing and harrowing operations resulted from the effect of soil pulverization, which offered little or no structural impedance to seedling emergence. The results are in line with the findings of Wlaiwan and Jayasuriya (2013) that evaluated the effect of different tillage and residue management practices on growth and yield of corn cultivation in Thailand and reported that sufficiently deeper plowing would be more effective in improving corn and biomass yields than shallow plowing. The poor vegetative growth and low yields in the no-tillage plots were caused by insufficient tillage and consequently by the quick weed emergence and competition with higher weed density. Deep tillage seemed to help deep-submerge of weed-seeds preventing their germination. Zorita (2000) reported an increase in vegetative growth and grain yield due to deep tillage on formerly no-tillage plots.

CONCLUSION

The disc plowing followed by disc harrowing treatment presented the lowest soil penetration resistance and dry bulk density, and the highest moisture content and total porosity. The no-tillage treatment produced the highest soil penetration resistance and dry bulk density, and the lowest moisture content and total porosity. The tillage treatments had no significant effect on the emergence of okra. The tillage methods affected the emergence of okra in the order of plowing and harrowing>plowing > no-tillage. The highest values of the number of emerged seeds, percentage emergence, emergence rate, and seed vigor index, and the lowest values of mean seed emergence time and seedling mortality rate obtained in the plowing and harrowing method might be due to reduced soil penetration resistance and bulk density, increased soil moisture content, enhanced seed-soil contact and suppressing weed growth. Where in case of plowing tillage only and no-tillage methods, the lower values of the number of emerged seeds, percentage emergence, emergence rate, and seed vigor index, and the higher values of mean seed emergence time and seedling mortality rate obtained may be due to significantly greater soil penetration resistance and bulk density, and lower soil moisture content. Therefore, plowing followed by harrowing method was found to be a more appropriate and profitable tillage method in improving soil physical properties and seed emergence, which will result in a high crop yield of okra. Under the soil and weather conditions of the experiment, the results indicate that the best tillage treatment for the production of okra is the disc plowing, followed by disc harrowing method.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

Agrawal, B. L. (1999). *Seed technology* (3rd ed.). Oxford and IBH Publishing Co. PVT. LTD. New Delhi, India. 829 p.

Aikins, S. H. M., & Afuakwa, J. J. (2012). Effect of four different tillage practices on soil physical properties under cowpea. *Agriculture and Biology Journal of North America*, *3*(1), 17-24. http://doi.org/10.5251/abjna.2012.3.1.17.24

Brady, N. C., & Weil, R. R. (1999). *The nature and properties of soils*, (12th edn.). Prentice Hall, Inc, New Jersey.

Cavalaris, C. C., & Gemtos T. A. (2004, June). Evaluation of tillage efficiency and energy requirements for five methods of soil preparation in the sugar beet crop. *Conference Book of Energy Efficiency and Agricultural Engineering*, Rousse, Bulgaria (pp. 110-116).

Christos, A. D., Spyridon, D. K., & Sideris, F. (2019). Hydro-priming effects on seed germination and field performance of faba bean in spring sowing. *Agriculture*, *9*, 201, 1-12. https://doi.org/10.3390/agriculture.9090201

Elder, J. W., & Lal, R. (2008). Tillage effects on the physical properties of agricultural organic soils of north-central Ohio. *Soil and Tillage Research*, *98*(2), 208-210. https://doi.org/10.1016/j.still.2007.12.002

Iqbal, M., Hassan, A. U., Ali, A., & Rizwanullah, M. (2005). Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum L.*). *International Journal of Agriculture and Biology*, *7*(1), 54-57.

Juan, S. G. J. A., Alfonso, L., Mario, E. V., David, S., Sergio, A. R., Miguel, Á. P., & Francisca, R. (2019). Seed physiological potential of *Capsicum annuum var. glabriusculum* genotypes and their answers to pre-germination treatments. *Agronomy*, *9*(6), 325, 1-12. https://doi.org/10.3390/agronomy9060325

Kader, M. A. (2005). A comparison of seed germination calculation formulae and the associated interpretation of resulting data. *Journal and Proceeding of the Royal Society of New South Wales*, *138*, 65-75.

Kasap, A., & Coskun, M. (2006). Sunflower yields and energy consumption as affected by tillage systems. *Asian Journal of Plant Science*, *5*, 37-40. https://doi.org/10.3923/ajps.2006.37.40

Khajeh-Hosseini, M., Lomholt, A., & Matthews, S. (2009). Mean germination time in the laboratory estimates the relative vigor and field performance of commercial seed lots of maize (*Zea mays* L.). *Seed Science and Technology*, *37*, 446-456. https://doi.org/10.15258/sst.2009.37.2.17

Khurshid, K., Iqbal, M., Arif, M. S., & Nawaz, A. (2006). Effect of tillage and mulch on soil physical properties and growth of maize. *American Journal of Agricultural and Biological Sciences*, *8*, 593-596.

Lampurlanes, J., & Cantero-Martinez, C. (2003). Soil bulk density and penetration resistance under different tillage and crop management systems and their relationship with barley root growth. *Agronomy Journal*, *95*, 526-536. https://doi.org/10.2134/agronj2003.5260

Lampurlanes, J., Angas, P., & Cantero-Martinez, C. (2001). Root growth, soil water content, and yield of barley under different tillage systems on two soils in semi-arid conditions. *Field Crops Research*, *69*(1), 27-40. https://doi.org/10.1016/S0378-4290(00)00130-1

Licht, M. A., & Al-Kaisi, M. (2005). Strips-tillage effect on seedbed soil temperature and other soil physical properties. *Soil and Tillage Research*, *80*(1), 233-249. https://doi.org/10.1016/j.still.2004.03.017

Mohammed, K. M., & Umogbai, V. I. (2014). Effects of levels of tillage on germination rate and vegetation of maize crop of Benue river Makurdi flood plains. *Asian Journal of Science and Technology*, *5*(2), 133-138.

Motavalli, P. P., Stevens, W. E., & Hartwig, G. (2003). Remediation of sub-soil compaction effects on corn N availability by deep tillage and application of poultry manure in a sandy-textured soil. *Soil and Tillage Research*, *71*(2), 121-131. https://doi.org/10.1016/S0167-1987(03)00041-2

Nkakini, S. O., Akor, A. J. Fila, I. J., & Chukwumati, J. (2008). Investigation of soil physical property and okra emergence rate potential in sandy loam soil for three tillage practices. *Journal of Agricultural Engineering and Technology (JAET)*, *16*(2), 34-43.

Ojeniyi, S. O., & Adekayode, F. O. (1999). Soil conditions and cowpea and maize yield produced by tillage methods in the rainforest zone of Nigeria. *Soil and Tillage Research*, *51*(1), 161-164. https://doi.org/10.1016/S0167-1987(99)00018-5

Olaoye, J. O. (2002). Influence of tillage on crop residue cover, soil properties, and yield components of cowpea in derived savannah ectones of Nigeria. *Soil and Tillage Research*, 64 (3-4), 179-187. https://doi.org/10.1016/S0167-1987(01)00261-6

Osunbitan, J. A., Oyedele, D. J., & Adekalu, K. O. (2005). Tillage effects on bulk density, hydraulic conductivity, and strength of a loamy soil in south-western Nigeria. *Soil Tillage Research*, 82 (1), 57-64. https://doi.org/10.1016/j.still.2004.05.007

Rashidi, M., & Keshavarzpour, F. (2008). Effect of different tillage methods on soil physical properties and crop yield of melon (*Cucumis melo*). *ARPN Journal of Agricultural and Biological Science*, *3*(2), 41-46.

Sauwa, M. M., Waniyo, U. U., Ngala, A. L., Yakubu, M., & Noma, S. S. (2013). Influence of tillage practices on physical properties of a sandy loam in semi-arid region. *Bayero Journal of Pure and Applied Sciences*, *6*(2), 76-83. http://dx.doi.org/10.4314/bajopas.v6i2.16

Wlaiwan, S., & Jayasuriya, H. P. W. (2013). Effect of different tillage and residue management practices on growth and yield of corn cultivation in Thailand. *Agricultural Engineering International: CIGR Journal*, *15*(3), 86-94.

Zorita, D. M. (2000). Effect of deep-tillage and nitrogen fertilization interactions on dryland corn (*Zea mays* L.) productivity. *Soil and Tillage Research*, *54*(1-2), 11-19. https://doi.org/10.1016/S0167-1987(99)00100-2