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EFFECT OF TILLAGE ON SOIL PHYSICAL PROPERTIES, GROWTH AND YIELD OF AMARANTH

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ABSTRACT

A study was conducted to determine the effect of tillage, namely, no-tillage (NT), slashing (SH), ploughing (PHO), ploughing plus harrowing (PHA), ploughing plus harrowing plus bedding (PHB), on soil physical properties, growth and shoot yield of large-green leafy amaranth (Amaranth sp.). Soil moisture retention and infiltration rates were also measured in two cropping seasons. Soil moisture retention did not reflect any significant differences in the first and second season at 0-10 cm depth. However, at 10-20 cm depth, PHA treatment gave the highest values at all the suction points ($P<0.5$) (56.6, 56.5, 54.8, 53.3, 52.4, 51.4 and 50.3%) except at 15,000 cm. Infiltration rate was highest in PHB (5.79 cm hr^{-1}) during the first season, while SH recorded the highest mean value in the second season (3.22 cm hr^{-1}). Leaf area and stem girth performed significantly ($P<.05$) better under PHO (76.0 cm^2) and PHB treatments (5.7 cm), respectively. In the first season harvest, PHO was better than other treatments (1.33 t ha^{-1}), while in the second season, PHB was superior to other treatments and was closely followed by PHO. However, in view of energy input, fuel consumption profile, costs outlay and soil nutrient dynamics, PHO is preferred as optimum tillage method for the cultivation of amaranths sp.

Key Words: Infiltration, saction, soil moisture retention, stem girth

RÉSUMÉ

Une étude était conduite pour déterminer les effets du labour: no-labour (NL), coupage (C) , labourage (L), labourage + hersage (LH), labourage+hersage+repiquage (LHR), sur les propriétés physiques de sols, la croisaance et le rendement en bourgeons des feuilles vertes larges amaranth (Amaranth sp.). L'humidité retenue dans le sol et les taux d'infiltration étaient mésurés pour deux saisons. L'humidité retenue dans le sol n'a pas varié significativement entre la 1ère et la 2ème saison pour une profondeur de 0-10 cm. Cependant, de 10 à 20 cm de profondeur, le traitement LH donna la valeur la plus élévée pour toutes les points de succions ($P<0.05$) (56.6, 56.5, 54.8, 53.3, 52.4, 51.4 et 50.3%) exception faite pour 15000 cm. Le taux d'infiltration était le plus élévé pour LHR (5.79 cm hr^{-1}) pendant la première saison, alors que C enregistra la valur moyenne la plus élévée pour la deuxième saison (3.22 cm hr^{-1}). La surface de la feuille et la circonférence des tiges étaient meilleures sous (L) (76.0 cm^2) et LHR (5.7 cm), respectivement. Dans la première saison de recolte, (L) était mieux que tous les autres traitements (1.33 t ha^{-1}), alors que pour la seconde saison, LHR était supérieur aux autres traitements suivit de plus près par L. Cependant, à l'égard de l'énergie dépensée, le profile de consommation du carburant, le coût des dépenses et la dynamique des éléments nutritifs, L est préférable comme méthode de labour optimum pour la culture de amaranths sp.

Mots Clés: Infiltration, succion, retention d'humidité dans le sol, circonférence de la tige

INTRODUCTION

Soil plays a predominant role as a reservoir of microorganisms which stimulate the physical processes affecting crop establishment and yield (Guerif *et al.*, 2001). The capacity of soils to sustain the nutrient cycles, energy flows through soil aggregates and ability to recover from degradation or deterioration after intensive exploitation depends on the tillage techniques. Doran and Parkin (1994-) confirmed the need to understand how biological, physical and chemical characteristics of soil are influenced by management practices. It is also generally accepted that the type of tillage system adopted for soil manipulation prior to planting does affect the geometry of the root systems, nutrient accessibility to plants and, consequently, crop establishment and growth (Ashraful *et al.*, 2001).

Although, the rate of root growth depends on the temperature, water and air supply in the soil, roots perform better and develop faster in porous soils (Russell, 1977; Ashraful, 2001). Porosity is a function of pore size distribution, pore continuity and hydraulic conductivity functions (Benjamin, 1993). The quality of soil pulverization in terms of aggregate size distribution resulting from the type of tillage techniques has a pronounced residual effect on saturated hydraulic conductivity, soil moisture retention characteristics and other physical properties that enhance suitable and sustainable soil structure. Soils that are structurally viable and stable for crop production can be identified by their structural properties which include infiltration rate and soil moisture retention (Aon *et al.*, 2001). Soil physical properties are affected by tillage systems with a residual influence on soil moisture reservoir, nutrient dynamics and crop performance. Hewit and Dexter (1980) reported that aeration and porosity in tilled plots were 30% higher than in untilled soils. Mean void size was 17% higher, while mean aggregate size was 30% larger in untilled than in tilled plots. However, the results obtained with respect to infiltration were not consistent. For example, Vervoort*et al.* (2001), Ehlers (1975) recorded an improvement on infiltration rate under untilled soils compared to tilled soils. Other investigators (Ankeny *et al.*, 1990; Suzel *et al.*, 1990; Heald *et al.*, 1998; Gomez *et al.*, 1999) could not establish any differences in infiltration rates between tilled and untilled soils. It is apparent that long- term research studies to predict soil response particularly infiltration rates to tillage practices using grain-amaranth as test crop is essential.

Effect of tillage systems on crop performance and yield have been extensively investigated under different crop (Dugas *et al.*, 1990; Moreno *et al.*, 1997; Benjamin, 1993; Aon *et al.*, 2000). In contrast, there is limited information about tillage influence on soil moisture retention and infiltration rates with respect to Amaranths sp.

Amaranth sp. (large - green) differs from other closely related crop. Its seeds are small, yet it matures within a short time. It decomposes fast, thereby, accelerating soil recovery from deterioration. The crop is rich in vitamins A and C (NAP, 1984).

The objective of this study was to determine changes in soil moisture retention and infiltration rates as a result of imposition of five tillage practices and using Amaranth as a test crop.

MATERIALS AND METHODS

An experiment was conducted at the National Horticultural Research Institute (NIHORT) at Ibadan, Nigeria. The area has a mean annual rainfall of 1300 mm.

Five tillage practices replicated three times in a randomised complete block design, were investigated. These were no-tillage (NT), slashing (SH), ploughing (PHO), ploughing plus harrowing (PHA), and ploughing plus harrowing plus bedding (PHB). In no-tillage, herbicide (glyphosate) was used to control weeds two weeks prior to planting. This was adopted to allow sufficient time for litter decomposition. Glyphosate was applied at the rate of 2.5 litres per hectare. Slashing was confined to ensure minimum soil pulverisation for effective seeding and seed- soil- water contact.

Ploughing involved the use of a disc plough mounted to a 60 HP tractor through the power take off shaft to adequately pulverise the soil to a level sufficient for seed germination and, consequent, seedling establishment. Ploughing plus harrowing were carried out using a combination of a disc plough and a disc harrow. The device was adopted to enhance more effective and improved soil tilth to ensure sufficient seed-soil contact. The ploughing, harrowing and bedding practice, reflecting the conventional cultivation practice for vegetable production in the south-west of Nigeria under mechanised farming, was the fifth tillage practice. This combined the use of disc plough, disc harrow and disc bedder improvised by NIHORT mounted to a 60 HP tractor at different times purposely for making vegetable flat beds in order to promote sufficient aeration, adequate drainage and smooth soil tilth.

The experimental design was randomised complete block with three replicates. Beds of one metre width, and 5 m length raised above 15 cm above the soil surface were prepared. This method reduces hazards of surface run-off and leaching.

Ten grammes (10 g) of amaranths seed were mixed with 1.75 kg of 0.2 to 0.02 mm sieved sand so as to protect the tender seeds from dehydration or from soil and aerial predators. The mixture of seeds and sand was sown to 5 m by 1 m plots. The 5 m by 1 m plot was cut out of 18 m by 1 m strip in all cases.

The soil moisture retention was determined at 10 cm to 50 cm suction using tension table apparatus (Richard and Finema, 1943). At 100, 300 and 1000 cm, soil moisture retention was evaluated using pressure plate apparatus (Kirchhoff and Basnet, 1989). Soil moisture retention at a suction point of 15000 cm was monitored by the maize grains method planted in tins (7 cm by 6 cm) at atmospheric pressure (improvised method). Soil samples were collected using 7cm by 7.5 cm soil cores following the core-sampling method of Cannel and Finney (1973) in three replicates.

The soil moisture retention was determined by saturating undisturbed soil samples contained in cylindrical soil core. The 7 cm diameter and 7.5 cm high cores containing soils were placed inside a metal chamber constructed of saturated ceramic plates. The determination was done following the method of (Richards and Finema, 1943). For 15,000 cm suction, an improvised method was considered.

Four maize grains were planted in each of the 10 tins collected randomly from each of the tillage practices. The grains were allowed to grow until 6 vigorous leaves were developed. At this point, the open ends of the tins were covered with paraffin wax to prevent evaporation from the soil surface. The plants in the tins were left to weather elements until they lost their turgidity.

The tins containing the turgid plants were placed under a humid condition (close to 100% relative humidity) by creating an open water surface in its vicinity. The plants were left to regain turgidity and were exposed to weather elements the following day. The moisture content at this stage was regarded as permanent wilting point at 15,000-cm suction.

Infiltration rates were measured using double ring infiltrometers (Kostiakov, 1932). The outer and inner rings were 60 and 20 cm diameter, respectively, and 20 cm high. The cumulative infiltration was plotted against time on a log - log scale. The slope of the graph at steady state was calculated. The infiltration data were fitted into Philip's equation (Equation 1).

$$1 = Ct^{\alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

I = cumulative infiltration per time (cm min^{-1})

C is a function of initial infiltration rate

t = elapsed time (min) and, α is a measure of structural stability

Log i was plotted against log t (Equation 2 and 3). The slope of the graph taken as α and the intercept, log C were used to determined both the sorptivity and transmissivity of the soils.

$$i = dI = St^{-1/2} + A \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$I = {}^{1}/_{2}\, t^{-1/2} + A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

I is cumulative infiltration
S is sorptivity
A is transmissivity and t is time (min).

Usually, S and A are obtained at 15 and 160 min elapsed time of infiltration, respectively. The slope S is the sorptivity, while the intercept is the transmissivity (assuming a homogeneous soil condition). This procedure was repeated for each treatment so as to compare the various tillage methods. Harvesting commenced four weeks after sowing during the 1995/1996 and April - July, 1996 planting seasons. Vegetables were cut at 15 cm height above the ground for all treatments and weighed using a top loading balance. Crop residues were left to decompose in the soil after each harvest in all treatments. Dry matters contents of 10 plants (both below and above ground portions) were determined fortnightly by oven drying at 103°C to constant weight. Roots were separated from the stem and the leaves. Leaf area was measured using the International Institute for Tropical Agriculture (IITA) model 3100 leaf area metre when the leaves attained optimum, development at five weeks after direct seeding. Plant height was measured at ground level to the trip of the terminal bud to the nearest centimeter, forthrightly using a graduated metre rule.

Stem girth was measured at ground level using a vernier caliper. Ten plants were chosen randomly out of a grid of 54 cm by 4 cm. Both root length and densities were determined using a metre rule and numerical continuing, respectively. Number of leaves was counted manually. The selected plants were removed by digging about 15 cm away from the stem and about 20 cm deep before a standard shovel was used to lift the plants to ensure minimum damage to the root system. Soil temperatures were monitored using mercury-in-glass thermometer at both 5 and 10 cm soil depth. Roots were washed with water after removal from the soil to eliminate the soils attached.

RESULTS AND DISCUSSION

Climate. The first cropping seasons (November 1995 to February 1996) had very low total rainfall (80.3 mm) though higher than the 10-year average of 70.2 mm (November 1988 - February 1998) (Table 1). Relatively low mean relative humidity (78.8%), high total evaporation (19.4 mm) and relatively high mean soil temperature were recorded compared with the second cropping seasons. The second season (April to July, 1996) recorded higher total rainfall (714.0mm), higher mean relative humidity (83.2%), with summation of mean daily evaporation for four months (16.7mm), mean sunshine hour (3.5 hr), mean net radiation (9.6 cal cm^2min^{-1}) and mean soil temperature (26.5°C). The result is typical of the bimodal rainfall pattern of the south-west of Nigeria. This trend affects the various weather inputs as reflected in the long-term (14-year averages) climate variability or normal rainfall pattern in south-western part of Nigeria.

Soil physical properties. Soil texture data are represented in Table 2. Sand accounted for about 90% of the texture confirming high porous soil profile in line with the soil texture data of the Institute experimental site. Organic carbon as well as bulk density also indicated some inherent levels of porosity of the soil. Figures 1(a) and 1(b) present the effect of tillage practices on soil moisture retention at different suctions (0-15000 cm) for two soil depths. There was no significance difference ($P<0.05$) among the tillage treatments. However, PHA was consistently highest except at

TABLE 1. Climate data for the experimental seasons at the NIHORT, Ibadan, Nigeria

Weather factors	1995				1996			
	Nov	Dec	Jan	Feb	April	May	June	July
Relative humidity (%)	81.6	77.7	82.5	82.5	84.3	77.3	83.1	88.3
Rainfall (mm)	25.6	0.5	0.0	54.2	215.6	115.0	169.1	214.9
Evaporation (mm day $^{-1}$)	4.0	4.8	4.6	6.0	4.3	4.5	4.2	3.7
Sunshine hour (hr)	5.8	4.8	3.5	3.9	4.0	4.3	3.6	2.0
Net radiation (cal. $cm^2 min^{-1}$)	11.0	10.2	9.8	9.6	9.7	9.4	9.7	8.7
Mean daily temperature (^{O}C)	26.8	26.0	26.8	28.0	25.4	27.4	26.4	25.0

15,000 cm suction where PHO held more moisture than all other treatments in the 0-10 cm depth. At 10-20 cm, PHB and PHA had the highest, while NT had the least. This trend could be due to the loosed tilled soils having relatively higher moisture flow as a result of more uniform aggregates. In tilled soils, there are greater possibilities of penetration of plough discs into the plough plan thereby reducing the turtuousity of soil water, while enhancing improved moisture movement within soil horizons.

TABLE 2. Soil texture, organic carbon content and bulk density of the soil at the study site at NIHORT, Ibadan, Nigeria (March 1996) at 0 - 15 cm soil depth

Tillage method	Texture			Carbon (%)	Bulk density (gcm^{-3})	Porosity (%)
	Sand (%)	Silt (%)	Clay (%)			
NT	88.4	6.0	5.6	0.88	1.58	50.2
SH	86.4	8.0	5.6	0.93	1.55	43.0
PHO	88.4	6.0	5.6	0.61	1.53	45.7
PHA	88.4	6.0	5.6	0.88	1.53	44.7
PHB	88.4	6.0	5.6	0.97	1.42	46.1
LSD 5(%)	NS	NS	NS	NS	NS	NS

NT = No -Tillage, SH = Slashing, PHO = Ploughing, PHA = Ploughing plus Harrowing, PHB = Ploughing plus harrowing plus bedding

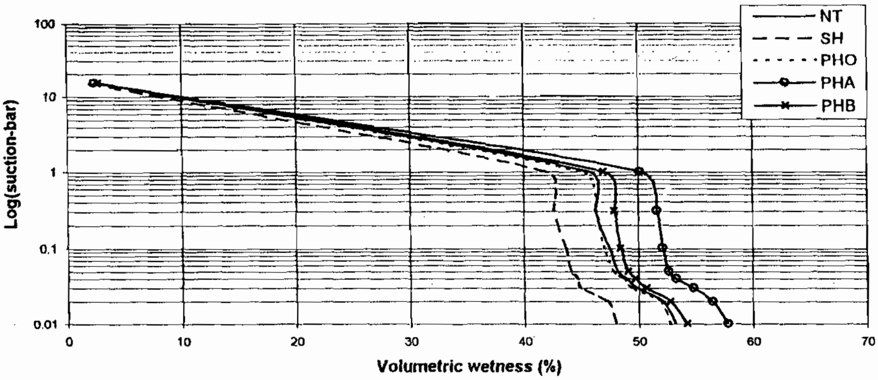

Figure 1a. Effect of tillage method on moisture retention at 0-10 cm (1st season) at NIHORT, Ibadan, Nigeria.

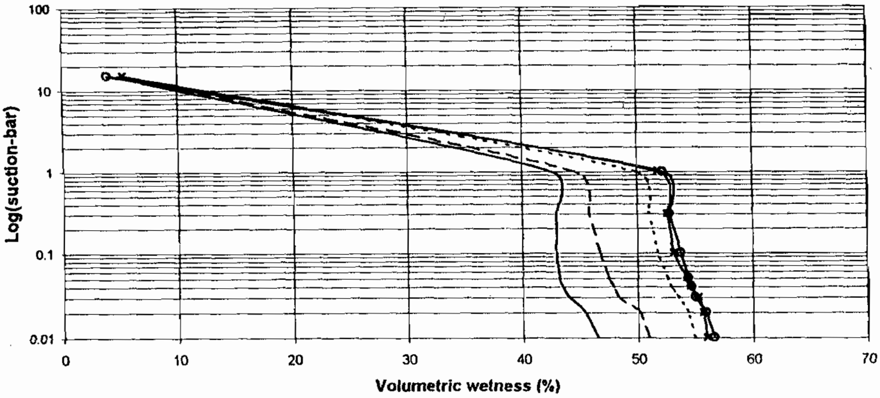

Figure 1b. Effect of tillage method on moisture retention at 10-20 cm (1st season) at NIHORT, Ibadan, Nigeria.

Soil moisture retention characteristics for the second season are presented in Figure 1(b). At 0-10 cm, in the second season, there were no significant differences (P <0.05). However, there was a little deviation as NT consistently produced the highest mean values at all the suction points, thus contrasting with PHA of the first cropping season (Fig. 2a). At 10-20 cm soil depth of the second season, a drastic change was observed (Fig. 2b), whereby PHA was consistently and significantly (P <0.05) higher than the rest of the treatments, except at 15,000 cm suction where NT recorded the highest mean value. There was, however, no significant differences (P <0.05) at the 15,000 cm suction point.

Field capacity assessed at 50 cm suction indicated that PHA was significantly (P<0.05) the highest. The permanent wilting points (PWP) were similar among the treatments. Generally, it was observed that PHA held more moisture, an indication of a soil profile with induced better structural stability than the rest treatments. The degree of significance was more consistent for PHA than for any other treatments. Spatial variability, long-term history of the soil cultivation or pore size distribution and soil cultivation implements configuration might be responsible for the outputs of the tillage practices and their effects on soil geometry over time.

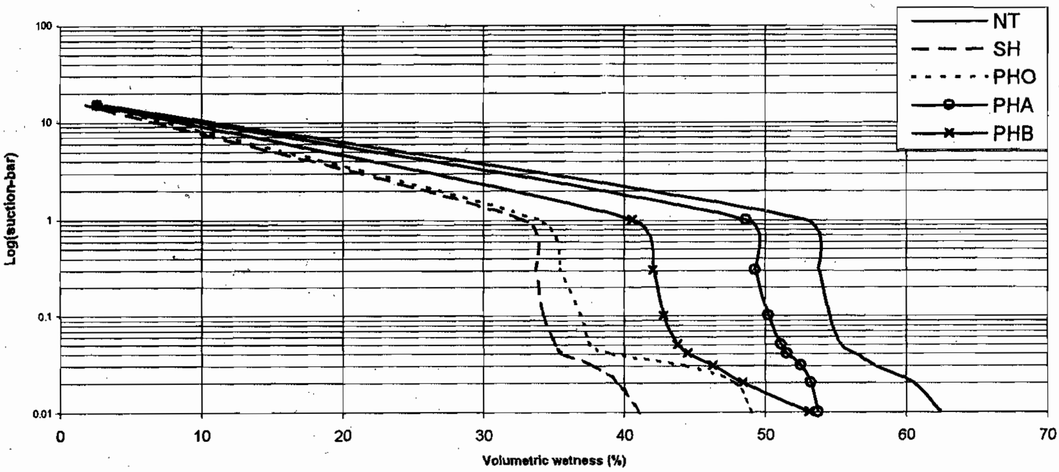

Figure 2a. Effect of tillage method on moisture retention at 0-10 cm (2nd season) at NIHORT, Ibadan, Nigeria.

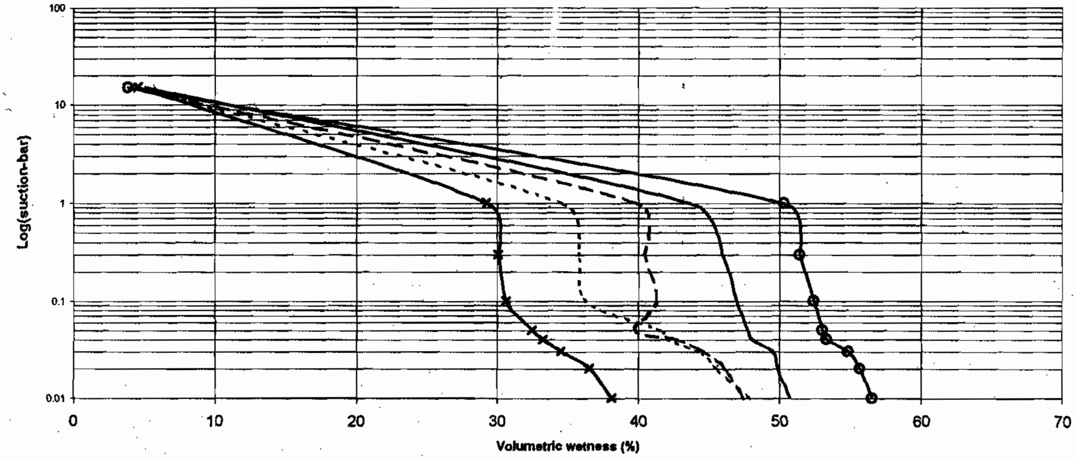

Figure 2b. Effect of tillage method on moisture retention at 10-20 cm (2nd season) at NIHORT, Ibadan, Nigeria.

The relationship between commutative infiltration rate and time is shown in Figures 3(a) and 3(b). There were no significant differences ($P<0.05$) among the tillage practices. The slopes and intercepts obtained from the cumulative infiltration against time on a log-log scale are generally referred to as measures of stability of soil structure and a function of initial infiltration rate (Kostiakov, 1932). The initial infiltration rate was in the order PHB > PHA> PHO> SH> NT. The stability indices also followed a similar trend with the initial infiltration rate (PHB = 0.31, PHA =0.27, SH = 0.21, PHO =0.14, NT = 0.04).

Figure 3(b) represents the graphical illustration of the trend of infiltration rate in the second season. Here, SH gave the highest infiltration rate at 3.22 cm hr^{-1}, while PHA was the least at 0.61 cm hr^{-1}. SH appeared less inhibiting to moisture flow, followed by NT from the regression equation generated (Fig. 3b). Initial infiltration values obtained from Fig. 3b are in the order SH (3.2 cm hr^{-1}) > NT (3.0 cm hr^{-1}) >PHO (1.6 cm hr^{-1}) > PHB (1.5 cm hr^{-1}) >PHA (0.61 cm hr^{-1}). NT, however, recorded the highest stability index (8.20), followed by SH (4.53) PHB (4.47), PHA (3.16) and lastly, PHO (2.95). The observed trend in

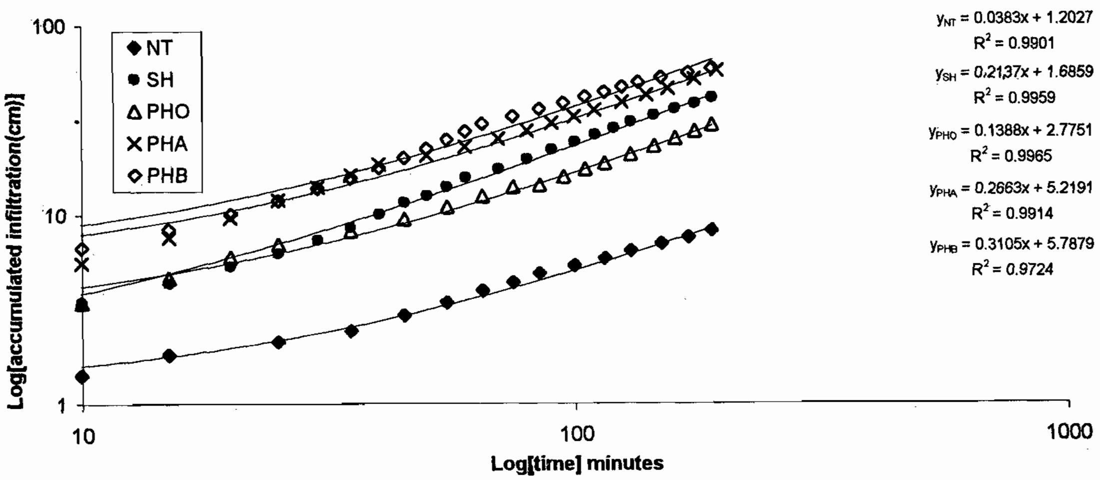

Figure 3a. Effect of tillage methods on infiltration capacity (1st season) at NIHORT, Ibadan, Nigeria.

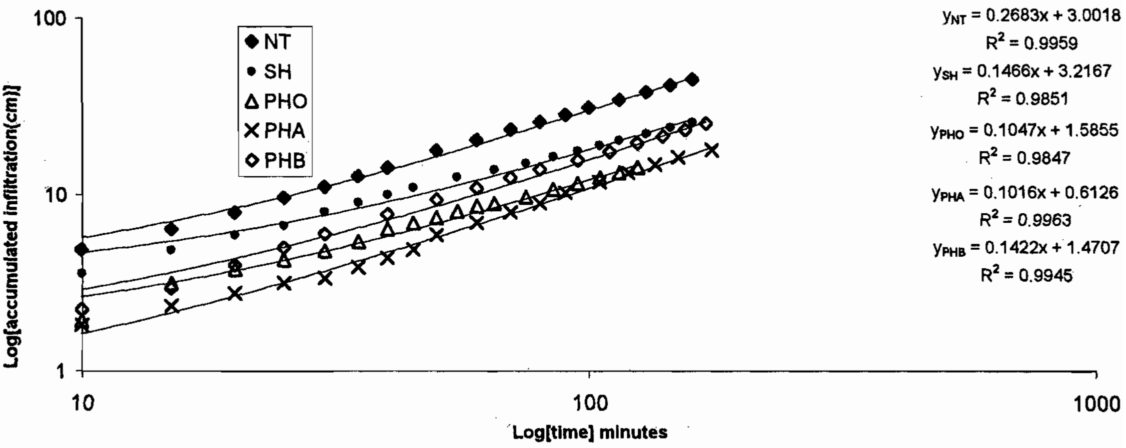

Figure 3b. Effect of tillage methods on infiltration capacity (2nd season) at NIHORT, Ibadan, Nigeria.

infiltration rates, transmissivity and sorptivity among tillage methods could be attributed to a number of factors such as differences in bulk densities, total porosity (Table 2) between the tilled and untilled, and soil pore configuration arising from the total porosity. This is generally considered as the simplest partial characterisation of the soil pore system (Vomocil, 1992). The slope of the curves at any point describes the rate at which water is absorbed by the soil (sorptivity), while the intercept is the soil transmissivity or hydraulic conductivity. Sorptivity values were observed to decrease with level of tillage activities (0.27, 0.15, 0.11, 0.10, and 0.14) except for a negligible increase between PHA and PHB. Transmissivity values followed a similar trend with slight deviation in NT. This could be attributed to a higher level of soil pulverisation typical of tilled than untilled soils, and also the structural pattern within the underlying soil profile coupled with the influence of plough pan affecting infiltration rate as reported by Pelegrin *et al.*, 1990) for similar experimental plots.

Crop performance. Crop growth results are presented based on seasons. The first season lasted four months beginning from November 1995 till February 1996 and the second one was between April to late July 1996. The effects of tillage practices on growth, shoot yield and weed density are shown on Tables 3 - 5. Generally, crop growth (leaf area) was significantly (P<0.05) superior under PHO except in the case of stem girth during the second harvest of the first season and the second harvest of the second season (12 weeks) after sowing, where PHB treatment recorded the best mean values in stem girth (Tables 3 and 4). Treatment PHB significantly influenced (P<0.05) shoot yield in the harvesting sequences, while the best PHO recorded the highest at the beginning of the cropping seasons. Where PHB was best, it was closely followed by PHO (Table 5). It was observed that plants in tilled plots performed better than untilled plots, especially with respect to leaf area, root density and shoot yield. In contrast, it was reported by Kerby *et al.*, 1980 that plants with smaller and more vertically displayed leaves encourage greater light penetration into the lower canopy strata. This phenomenon enhances CO_2 compensation point of the bottom leaves, although

TABLE 3. Effect of tillage method on the growth of leafy amaranth (Large Green) during the November 1995 - February 1996 at NIHORT, Ibadan, Nigeria

Tillage method	1st harvest						2nd harvest					
	LAP (cm²)	NLP (cm)	RDP (cm)	SGP (cm)	NRP	PHP (cm)	LAP (cm²)	NLP (cm)	RDP (cm)	SGP (cm)	NRP	PHP (cm)
NT	47.5	15.3	17.1	5.3	24.3	33.0	28.5	12.0	13.6	4.7	22.0	22.7
SH	44.3	16.0	17.3	4.0	22.0	28.3	33.2	13.0	14.9	3.7	19.0	28.7
PHO	74.4	16.0	17.4	5.0	21.0	29.9	76.0	15.0	21.8	4.3	26.0	43.1
PHA	52.2	16.0	17.0	3.9	22.0	25.8	33.9	13.0	20.3	3.8	26.3	23.1
PHB	58.4	15.0	16.5	5.2	26.0	29.6	40.1	14.0	20.0	5.7	21.0	30.2
LSD (5%)	38.9	ns	ns	ns	ns	ns	25.6	ns	ns	1.4	ns	ns

LAP = Leaf area per plant; NT = no-tillage, NLP = no. of leaves per plant; SH = slashing, RDP = root depth per plant. PHO = ploughing; SGP = stem girth per plant; PHA = ploughing plus harrowing; NRP = no. of root per plant; PHB = ploughing plus harrowing plus bedding; PHP = plant height per plant

TABLE 4. Effect of tillage method on the growth of leafy amaranth (Large Green) during the April - July 1996 season at NIHORT, Ibadan, Nigeria

Tillage method	1st harvest						2nd harvest					
	LAP (cm²)	NRP (cm)	PHP (cm)	RDP	NLP (cm)	SGP	LAP (cm²)	NRP (cm)	PHP (cm)	RDP (cm)	NLP	SGP (cm)
NT	34.725	24.000	33.000	17.050	15.00	5.275	28.475	22.00	22.675	13.600	12.00	3.650
SH	42.175	22.000	28.250	17.250	16.00	2.950	33.225	19.00	28.700	14.900	19.000	4.275
PHO	45.225	21.000	25.850	15.400	16.00	5.025	76.000	26.000	34.100	18.825	13.000	4.700
PHA	47.875	22.000	25.775	17.025	16.00	3.925	33.850	26.000	23.100	20.325	13.000	3.8000
PHB	25.400	26.000	27.625	16.525	15.000	5.150	40.125	21.000	30.100	20.025	14.000	5.700
LSD (5%)	ns	ns	ns	ns	ns	ns	25.619	ns	ns	1.4	ns	1.370

luxuriant leaf development has been considered not a desirable index for crop performance (Hraska, 1995). The trend in the degree of significance confirms that an optimum level of soil tilth and manipulation are essential for cultivation of vegetable. Besides, the quantity of fuel consumed coupled with the number of traffic passes typical of PHB and PHA, suggest that PHO would be preferred as it conserves energy and is cost saving. In untilled plots (NT, SH), the level of soil pulverisation was greatly reduced. NT and SH treatments gave the highest mean weed density ($P<0.05$) (Table 5). Amaranth sp. is not only a short duration crop but also develops faster to maturity. This could explain why mean weed density for PHB, PHA and PHO were similar, but less than in NT and SH.

In view of the soil disturbance and consequence incorporation of weeds into the soil during cultivation as in the cases of PHO, PHA and PHB, weed seeds would have been exposed to environmental hazard, therefore, becoming dormant for a long time prior to emergence. Weed emergence became move pronounced under untilled plots (NT, SH). Incorporation of stubbles into the soil during NT and SH activities could be hindered as they were left on the soil surface with weed seeds having potentials of early sprouting. Competition of weeds with Amaranth sp. could have, among other reasons and factors, possibly reduced the yield of NT and SH treatments.

Overall results revealed that PHO tillage practice would be preferred to other treatments in amaranth sp. production.

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TABLE 5. Effect of tillate methods on the shoot yield of grain amaranth (t ha^{-1}) and mean weed density (t ha^{-1}) at NIHORT, Ibadan, Nigeria.

Tillate method	1st season		2nd season		
	1st season	2nd season	1st season	2nd season	Mean weed density
NT	0.68	0.28	2.5	3.20	4.2
SH	0.14	0.29	3.3	2.6	3.9
PHO	1.33	0.52	5.1	3.1	2.9
PHA	1.00	0.20	1.9	2.1	1.9
PHB	0.76	0.79	8.2	7.5	1.6
LSD (5%)	0.81	0.17	3.6	3.3	1.9

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