EFFECT OF TILLAGE AND WEEDING REGIMES ON WEED SUPPRESSION AND ROOT YIELD OF SWEET POTATO IN TWO AGRO-ECOLOGIES OF NIGERIA.

Korieocha, D.S[1], Udom G.N[2] and Nwokocha, C.C.[1]
1.National Root Crops Research Institute UmudikeAbia State, Nigeria.
2. University of Uyo, Uyo Nigeria.
Corresponding Author email:davesam2k@gmail.com and davesam2k@yahoo.com.
Tel: 08165116081

ABSTRACT
A field study was carried out in two agro-ecologies, namely, rainforest and derived guinea savanna vegetational belts. The trials were located at the National Root Crops Research Institute, Umudike (Rainforest) and the sub-station at Otobi (derived Guinea Savanna) in 2017 and 2018 cropping seasons to determine the effects of different tillage methods on weed control and yield of sweetpotato. The plot size was 5 m x 6 m (30 m^2), spaced 0.3 m within and 1 m between the rows. The experimental design was split plot design, replicated 3 times, the test crop was sweetpotato variety 87/0087. The treatments consisted of 3 levels of tillage (mounds, ridge and flat) which occupied the main plots and 3 levels of weeding regimes (No manual weeding, manual weeding at 4 WAP and manual weeding at 8 WAP) which occupied the sub-plots. All data collected were subjected to Analysis of Variance (ANOVA), using Genstat Discovery Edition 2. Means were separated using FLSD at 5% level of probability. Results showed that tillage system significantly ($P < 0.05$) affected mean weed density at Umudike. Ridge methods recorded the lowest mean weed density (6.1 m^2) and biomass and also highest root yield (18.92 and 15.20 t/ha) when compared to other treatment in both locations, combination of ridging methods with manual weeding at 8 WAP is recommended for producers in the sweetpotato value chain in both zones.

Keywords: Economics, Sweetpotato, Tillage, Weeding regimes, vegetation.

INTRODUCTION

Sweetpotato (*Ipomoeabatatas*[L.] Lam) is a creeper of the *Convolvulaceae* family. It is believed to have originated from either Central America or within the tropical region of the North western parts of the Central America (Onwueme and Charles 1994; Hahn and Hozyo, 1984). Sweetpotato was brought to Nigeria by the Spanish and Portuguese explorers (Agbo and Ene, 1994).The cultivation of the crop started around 3000 BC and it is now grown throughout the tropics, sub tropics and warm temperate zones of both hemispheres. It grows well in high altitude up to 2300 meters above sea level and between 30^o North and 30^{o}South of the equator (Hahn and Hozyo, 1984).

Sweetpotato is used to alleviate poverty and ensure food security in Sub-Sahara Africa due to its productivity per unit area and time (NRCRI, 2005). Farmers in more than 100 countries rely on environmental resilience of sweetpotato to produce high yields in marginal soils with minimum investment (Horton *et al*., 1989). Intercropping sweetpotato with different crops for example legumes, cereals, root and tuber crops have been reported (Onwueme and Charles, 1994; Udealor and Ezulike, 2011).

The competitive nature of weeds in annual and perennial crops has been documented (Melifonwu, 1994; Alabi, 1999). Weed competition poses a serious problem in sweetpotato production and uncontrolled weed growth causes 57 - 82% reduction in fresh root yield of sweetpotato (Unamma, 1981).

Soil tillage helps to control weeds in many ways (Lal, 1976). It alters the weed – soil relationship, it destroys weed seedlings by uprooting, smothering, dessicating, decomposing or weakening weed plants through dislodging, damaging, depleting food resources and root pruning. Tillage induced changes in the soil physical environment determining the abundance of safe sites (Hatfield *et al*., 1999), which could affect the establishment of weed population (Buhler, 1995). Tillage influences the composition and density of weed seeds and diversity of weed species (Streibig, 1988; Wilson, 1988; Ball and Miller, 1993). Hence there is need to determine the effects of different tillage methods on weed control and yield of sweetpotato.

MATERIALS AND METHODS

Study Area

Field trials were conducted at the National Root Crop Research Institute Farm between May 2017 and November 2018 at two locations, Umudike, Abia State (Latitude 05^0, 29^{1}N, and Longitude 07^0, 33^{1}E and 122 m above sea level) and Otobi Sub Station in Benue State (Latitude 07^0, 19^{1}N, and Longitude 08^0, 32^{1}E and 141 m above mean sea level) (measured using the Global Positioning System (GPS), Model Garmin Extrex) manufactured by Garmin Ltd. Olathe, Kansas City U.S.A.

The site at Umudike represented the moist forest agro-ecology with tropical rainforest vegetation but much of it had been cleared for the cultivation of arable crops. Before this study the experimental site had been under intensive research cropping to cassava, yam, maize; fluted pumpkin and cocoyam. The land was under one year fallow after fluted pumpkin was harvested, prior to the present studies. The soil of Umudike is acidic and belongs to broad soil classification group Ultisol, derived fromcoastal plain sands of Benin formation - low in organic matter and other nutrients. The area has a mean annual rainfall range of 1800-2200 mm (Collins, 1995). Rainfall pattern is bimodal having peaks in July and September. The site of Otobi represented the wet and dry agro-ecology of the derived guinea savannah and had been under intensive cultivation for research on cassava, yam, maize, guinea corn, sweet potatoes and groundnut.

The composition of the fallow vegetation at the two sites was determined by the throwing a 1 x 1 m quadrat randomly and counting the number of plant stand within the quadrat. The plant types were classified as grasses, broadleaves and sedges, expressed as percentage. Sampling of the fallow vegetation using the 1x1 m quadrat was repeated ten times. The population of each class was estimated as the mean of the ten samples.

Soil Sampling and Analysis

Composite soil samples were collected before land preparation at depths of 0 – 15 cm and 15 -30 cm in both locations and years, with the aid of soil auger. Samples were bulked, bagged, labeled and taken to the National Root Crop research Institute Soil Science Laboratory Umudike for analysis, for its physical and chemical properties as described by Carter (1993). The sample were dried, crushed and sieved using a 2 mm sieve. Particle size analysis was determined by the Bouyoucos hydrometer according to Gee and Bauder(1986). Total N wasdetermined by the Micro-Kjeldahl method as described by Bremner and Mulvaney (1982). Soil pH was determined in a 1:2.5 soil towater suspension using a pH meter (Mclean, 1982).Organic carbon was analyzed following Walkley and Black dichromate (wet) oxidation (Nelson and Sommers, 1982). Organic matter was estimated as organic carbon multiplied by 1.724 (Bremner,1996). Available phosphorus was analyzed using Bray-11 method as described by Olsen and Sommers (1982). Potassium, magnesium, calcium and sodium were extracted using NH_4OAC and their values determined by the flame photometer (Thomas, 1982). Exchangeable acidity (H^+ + Al^{3+}) was determined bytitration method (Anderson and Ingram, 1993),Effective Cation Exchange Capacity (ECEC) wascalculated by the summation of the exchangeablebases and acidity (Tan, 1996).Base saturation (%)was calculated as the sum of the exchangeable basesdivided by ECEC and multiplied by 100.

Experimental Protocol

The experiment was laid out in a split plot design replicated three times. The main plot treatments consisted of three tillage methods, namely; mounds, ridges and flat, and the sub treatments comprised three levels of manual weeding regimes viz; no weeding, manual weeding at 4 WAP and manual weeding at 8 WAP. Plot size was 5 m x 6 m . The main and the sub plots were delineated with a 2 m alley. Vine cuttings of sweetpotato (87/0087) with 4-5 nodes about 30cm long were planted one per stand at a spacing of 100 cm by 30 cm to give a plant population of 33,333 plants $ha^{-1.}$ .In the mounds treatment plots, each row contains four mounds each with five stands of sweetpotato, giving 100 stands/plot. Planting was done and NPK (15:15:15) fertilizer was basally applied at the rate of 400 kg/ha at 4 WAP, Harvesting and determination of yield data were done at 5 MAP.

Data Collection and Analyses

Sweetpotato growth and yield data were collected from 5 randomly tagged sweetpotato plants at the middle of each plot. Assessment of the growth performance of sweetpotato was done at four weekly intervals. The following parameters were measured: establishment percentage, sweetpotato shoot dry weight, total root yield, weed data, and economics of tillage and weeding regimes

Data collected were subjected to analysis of variance (ANOVA) using Genstat statistical package,(Edition 4 of 2012). Treatment means were compared using the Fishers least significant difference at 5% level of probability. In addition, economic assessment of weed control treatments were subjected to partial budget model expressed as follows:

NB = GB – TV------------ (Eqn 1)

MRR = NB/TVC ------------ (Eqn 2)

Where

NB = Net benefit measured in Naira

GB = Gross farm gate benefit, derived as yield of sweetpotato in tonnes per hectare, multiplied by the farm gate price measured in naira.

TVC = Total variable cost of all inputs and resources used, measured in naira.

MRR = Marginal rate of return, derived as a ratio of the change in benefit to change in total variable cost of inputs in each treatment expressed in percentage.

RESULTS

General Properties of the Soils of the Experimental Sites

The soil physico-chemical properties of the experimental sites are as shown in Table 1. The particle size distribution showed that Umudike soil had a loamy sand texture and a sandy loam texture in 2017 and 2018 cropping seasons, respectively, while Otobi soil was loamy in 2017 and sandy loam in 2018.Umudike soils were strongly acid, having pH values in the range of 5.1 – 5.5. However, Otobi soils were moderately acid with pH value in the range of 5.6 – 6.0. Soil organic matter was low (< 20 g kg^{-1}) in both locations. The soils of both sites were generally low in total nitrogen (< 1.5 g kg^{-1}) in both years. Available P was medium in Umudike soils (15 – 25 mg kg^{-1}) and high in Otobi soils (> 25 mg kg^{-1}). Cation exchange capacity was low, while base saturation was high at both locations across the years.

Establishment Percentage

The effect of tillage and weeding regimes on establishment percentage of sweetpotato at Umudike and Otobi in 2017 and 2018 seasons is presented in Table 2. Neither tillage method nor weeding regime significantly (P > 0.05) influenced establishment percentage of sweetpotato in both seasons and locations. Similarly, there was no significant interaction effect of tillage x

Table 1. Initial soil physico-chemical properties of the study locations in 2017 and 2018 cropping seasons (Mean of 2 depths)

Soil properties	2017 Cropping season		2018 Croppingseason	
	Umudike	Otobi	Umudike	Otobi
Sand g/kg	784	514	744.5	584.5
Silt g/kg	124	294	123.8	229.0
Clay g/kg	92	192	131.7	186.5
Soil texture	LS	L	SL	SL
pH	5.40	5.60	5.40	5.56
Organic matter (gkg^{-1})	16.6	17.6	16.8	17.6
Total Nitrogen (gkg^{-1})	0.80	0.90	0.80	0.90
Available P ($mgkg^{-1}$)	19.45	34.65	20.25	33.65
Calcium ($cmolkg^{-1}$)	3.40	4.20	3.44	4.2
Magnesium ($cmolkg^{-1}$)	2.00	2.60	2.01	2.67
Sodium ($cmolkg^{-1}$)	0.11	0.13	0.11	0.13
Potassium ($cmolkg^{-1}$)	0.09	0.08	0.06	0.09
Exchangeable acidity ($cmolkg^{-1)}$	1.04	1.12	1.06	1.16
Organic carbon (gkg^{-1})	9.6	10.2	9.4	10.3
Effective cation exchange capacity ($cmolkg^{-1}$)	6.46	8.13	6.68	8.25
Base saturation (%)	83.90	86.22	84.13	85.94

LS = Loamy sand; L = Loam; SL = Sandy loam.

Table 2. Sweetpotato establishment percentage as influenced by tillage and manual weeding at Umudike and Otobi in 2017 and 2018 cropping season

	Umudike Establishment %		Otobi Establishment %	
Treatment	**2017**	**2018**	**2017**	**2018**
Tillage method				
Flat	76.33	80.60	70.8	76.3
Mounds	82.89	91.20	80.3	72.7
Ridge	82.67	90.80	83.3	81.7
LSD (0.05)	NS	NS	NS	NS
Weeding regime				
Hand weeding 4 WAP	80.67	85.40	83.2	76.60
Hand weeding 8 WAP	84.22	85.30	86.6	80.00
Unweeded	77.00	86.00	86.7	80.0
LSD (0.05)	NS	NS	NS	NS
Tillage x Weeding regime Interaction	NS	NS	NS	NS

NS=Not significant at 5% level of probability; WAP = Weeks after planting

weeding regime effect on percentage establishment of sweetpotato in both seasons and locations. In Umudike location, percentage establishment ranged from 76.33 – 91.20%, while in Otobi location it ranged from 70.80 – 81.70%.

Weed Density

The effect of tillage and manual weeding regimes on weed density in sweet potato plots in 2017 and 2018 at Umudike and Otobi is presented in Table 3. Tillage and weeding regimes significantly (P< 0.05) affected weed density in sweetpotato plots at Umudike and Otobi in both seasons. At Umudike, the use of ridge at 12 weeks in 2017, and at 8 and 12 weeks in 2018 resulted to the lowest weed density in sweetpotato plots. Otherwise, either the use of ridges or mounds had similar effect on weed density, that were significantly lower than those from flat, The flat in both seasons produced significantly higher weed densities. At Otobi, the ridges or mounds treatment did not affect weed density differently, in sweet potato plot in both seasons except at 12 WAP in 2017 where ridges produced significantly least weed density followed by those from mounds plots, while the flat plots produced the highest weed density in sweet potato plots in both seasons.

Amongst the manual weeding treatments, weeding at either 4 or 8 weeks of observation did not differ in their effect on weed density in sweet potato plots, but produced similar weed densities that were significantly (P< 0.05) lower than those of the unweeded plots in both seasons and at both locations. The interaction between tillage and manual weeding regimes on weed density in sweetpotato plots was not significant in both years and locations.

Table 3. Weed density (m^{-2}) as influenced by tillage and manual weeding regimes at Umudike and Otobi in 2017 and 2018 cropping seasons.

	Umudike						**Otobi**					
	2017 Weeks After Planting			**2018 Weeks After Planting**			**2017 Weeks After Planting**			**2018 Weeks After Planting**		
	4	**8**	**12**	**4**	**8**	**12**	**4**	**8**	**12**	**4**	**8**	**12**
Tillage												
Flat	29.2	57.7	126.7	30.1	53.3	106.7	45.0	72.9	122.9	39.3	66.1	83.5
Mounds	15.8	31.6	30.2	11.4	27.4	23.4	18.7	42.6	31.4	17.3	37.8	27.4
Ridge	15.0	25.6	23.2	9.3	23.9	18.2	17.3	37.2	25.0	15.7	34.1	22.6
$LSD_{(p<0.05)}$	6.14*	13.03*	6.75**	3.75*	2.80*	3.03**	7.31*	6.83*	3.30**	6.85*	8.30*	8.74**
Weeding regime												
Hand weeding 4 WAP	16.3	31.1	38.3	11.1	28.0	26.9	22.9	41.6	33.9	19.7	36.8	29.5
Hand weeding 8 WAP	13.8	28.4	28.3	11.9	26.4	27.6	20.4	41.2	32.9	18.2	39.3	30.0
Unweeded	29.8	55.3	113.4	27.8	50.2	93.8	37.6	69.9	112.4	34.4	61.9	74.1
$LSD_{(p<0.05)}$	4.20*	8.10*	34.08**	2.85*	2.68*	5.43**	5.51*	12.21*	2.15**	8.80*	7.41*	7.99*
Tillage x weeding regime interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

***, ** = Significant at 5% and 1% probability levels, respectively; NS = Not significant at 5% probability level; WAP = Weeks after planting.**

Weed Biomass

The effect of tillage and weeding regimes on weed biomass in sweet potato plots at Umudike and Otobi in 2017 and 2018 in presented in Table 4. Tillage and weeding regimes affected weed biomass significantly (P< 0.05) in both years and locations. The weed biomass followed the trend of weed population density. In all sampling periods except at 4 and 8 weeks of observation, where weed biomass was not affected by tillage practices adopted, the use of ridges or mounds did not differ on their effect on weed biomass from sweetpotato plots, but gave significantly lower weed biomass than those from the flat plots; in both locations and seasons. Amongst the weeding regimes, the unweeded plots gave sweetpotato plots with highest weed biomass in both locations and seasons. Weeding sweetpotato plots at either 4 or 8 WAP resulted to statistically similar weed biomasses that were lower than biomass from the unweeded plots.

The interaction between tillage methods and weeding regimes on weed biomass was not significant.

Total Root Yield

The effect of tillage and weeding regimes on total root yield of sweetpotato at Umudike and Otobi in 2017 and 2018 is presented in Table 5. The results revealed that total root yield of sweetpotato was significantly (P < 0.05) affected by the tillage practices and weeding regime adopted at both locations and seasons. At Umudike in both seasons, planting of sweetpotato on ridges produced a total root yield that was significantly higher than those from mounds and flat, while planting on flat gave the lowest total root yield. This trend was also observed at Otobi in 2017, but in 2018, ridges performed better than flat but were similar to mounds in terms of total root yield of sweetpotato.

Amongst the weeding regimes, weeding at 8 WAP produced sweetpotato with significantly higher total root yield at Umudike in both seasons and Otobi in 2017, than weeding at 4 WAP.

Table 4: Weed biomass in sweetpotato field as influenced by tillage and manual weeding at Umudike and Otobi in 2017 and 2018 cropping season

	Umudike						Otobi					
	2017 Weeks After Planting			2018 Weeks After Planting			2017 Weeks After Planting			2018 Weeks After Planting		
Treatment	**4**	**8**	**12**	**4**	**8**	**12**	**4**	**8**	**12**	**4**	**8**	**12**
Tillage method												
Flat	1.86	1.84	3.32	1.28	1.94	2.89	2.51	2.58	2.43	1.48	2.90	3.21
Mounds	1.40	1.12	1.15	0.52	0.99	0.94	0.87	0.97	0.87	0.62	1.01	1.06
Ridge	1.12	1.04	0.82	0.48	0.89	0.70	1.28	1.51	0.76	0.46	0.96	0.75
$LSD_{(p<0.05)}$	0.88*	NS	1.85*	0.73*	0.17*	0.63**	1.56*	1.09*	1.30*	0.61*	0.63*	0.85**
Hand Weeding												
Hand weeding 4 WAP	1.02	0.92	1.54	0.49	0.88	0.93	1.02	1.28	1.08	0.63	0.89	0.85
Hand weeding 8 WAP	0.86	1.54	0.77	0.60	1.07	0.81	0.94	0.90	0.71	0.60	1.51	0.75
Unweeded	2.50*	1.53	2.98	1.18	1.85	2.80	2.71	2.88	2.28	1.33	2.47	3.45
$LSD_{(p<0.05)}$	0.62	0.69*	0.92*	0.48*	0.44*	0.43*	1.07*	0.94*	0.82*	0.29*	0.72*	1.25**
Tillage x weeding regime interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

***, ** = Significant at 5% and 1% probability levels, respectively; NS = Not significant at 5% probability level; WAP = Weeks after planting.**

Table 5. The effect of tillage and weeding regime on total root yield at Umudike and Otobi in 2017 and 2018 cropping seasons.

	Umudike		Otobi	
	2017	2018	2017	2018
Tillage method				
Flat	8.02	3.80	8.57	4.00
Mounds	12.07	5.23	13.14	5.66
Ridge	14.03	6.70	16.67	7.37
LSD $_{(p<0.05)}$	1.55*	1.01*	1.77*	2.75*
Manual weeding				
Hand weeding 4 WAP	11.67	4.87	12.81	5.29
Hand weeding 8 WAP	13.74	6.82	16.74	7.58
Unweeded	8.70	4.01	8.82	4.10
LSD $_{(p<0.05)}$	3.51*	0.65*	2.80*	2.81*
Tillage x weeding regime interaction	NS	NS	NS	NS

*** = Significant at 5% probability level; NS = Not significant at 5% probability level; WAP = Weeks after planting.**

Weeding at either 4 or 8 WAP produced similar effect on total root yield of sweetpotato at Otobi in 2018. However, the unweeded plots produced sweetpotato with least total root yield at both locations and seasons except at Otobi in 2018 when weeding at either 4 WAP or the unweeded had statistical similar effect on sweetpotato total root yield. Interaction of tillage and weeding regimes was significant on total root yield of sweetpotato at Otobi in 2017.

Economics of Tillage Method and Weeding Regime on Sweetpotato Yield at Otobi and Umudike in 2017 and 2018 Cropping Seasons

The economics of tillage methods and weeding regimes in sweetpotato field at Otobi and Umudikein 2017 and 2018 seasons are as presented in Tables6 and 7. The analysis showed that in Otobi, total variable cost (TVC) ranged from ₦255,000.00. (obtained from plots without weeding, irrespective of tillage method adopted) to ₦319,000.00(obtained plot that were weeded

Table 6 Economics of tillage methods and weeding regimes on sweetpotato yield at Otobiin 2017and 2018 cropping Seasons(average of 2 year).

Treatments	Mean Yield t/ha	Total Variable Cost (TVC) ₦ /ha	Price of Root ₦ /t	Gross Revenue ₦ /ha	Gross Margin ₦ /ha	Return per Naira Investment	Ranking
Flat + No Manual weeding	5.36	255,000	20,000	107200	-147,800	-1.58	7
Flat + 4WAP	6.875	319,000	20,000	137500	-181,500	-1.57	8
Flat +8WAP	6.615	319,000	20,000	132300	-186,700	-1.59	9
Mounds +no manual weeding	7.495	255,000	20,000	149900	-105,100	-1.41	3
Mounds +4WAP	9.675	319,000	20,000	193500	-125,500	-1.39	6
Mounds +8WAP	10.945	319,000	20,000	218900	-100,100	-1.31	2
Ridge +No manual weeding	6.53	255,000	20,000	130600	-124,400	-1.49	5
Ridge +4WAP	10.595	319,000	20,000	211900	-107,100	-1.34	4
Ridge +8WAP	18.92	319,000	20,000	378400	59,400	1.19	1

WAP = Weeks after Planting

Table 7. Economics of tillage methods and weeding regimes on sweetpotato yield at Umudikein 2017 and 2018 cropping seasons (average of 2 year).

Treatments	Mean Yield t/ha	Total Variable Cost (TVC) ₦ /ha	Price of Root ₦ /t	Gross Revenue ₦ /ha	Gross Margin ₦ /ha	Return per Naira Investment	Ranking
Flat + No Manual weeding	5.05	255,000	20,000	101000	-154,000	-1.6	9
Flat + 4 WAP	6.56	319,000	20,000	131200	-187,800	-1.59	8
Flat +8 WAP	6.12	287,000	20,000	122400	-164,600	-1.57	7
Mounds +no manual weeding	7.19	255,000	20,000	143800	-111,200	-1.44	5
Mounds +4 WAP	9.23	319,000	20,000	184600	-134,400	-1.42	3
Mounds +8 WAP	9.52	287,000	20,000	190400	-96,600	-1.42	2
Ridge +No manual weeding	6.8	255,000	20,000	136000	-119,000	-1.47	6
Ridge +4 WAP	9.1	319,000	20,000	182000	-137,000	-1.43	4
Ridge +8 WAP	15.2	287,000	20,000	304000	17,000	1.06	1

WAP = Weeks after Planting at either 4 or 8 WAP under the different tillage methods).

The innovation of the use of ridges + weeding at 8 WAP gave a gross revenue of ₦218,900.00, with a gross margin of ₦59,401.00 and a return of ₦1.19 to every one naira invested to rank first. This was followed by the use of mounds + weeding at 8 WAP, which however recorded a negative gross margin of ₦-100,100.
The economics of tillage methods and weeding regimes in sweet potato production at Umudike in 2017 and 2018 season in Table 7showed that the total variable cost (TVC) ranged from ₦255,000.00 obtained from plots without weeding irrespective of the tillage method adopted to ₦319,000.00 in plots weeded at 4 WAP under any of the tillage methods. The innovation of ridges + manual weeding of at 8 WAP gave a gross revenue of ₦304,000.00 resulting in a Gross margin of ₦17,000.00 per hectare and ranking first with a return of ₦1.06 for every one naira invested in the production of sweetpotato at Umudike. This was followed by the use of mounds + weeding at 8 WAP, which however recorded a negative gross margin ₦–96,600.00

DISCUSSION

In this study, tillage methods significantly (P<0.05) influenced weed population density, biomass and weed type count in both locations and seasons. This is in line with Barberi (2001) who reported that changes on weed specie composition could occur by adoption of tillage methods. Also Liebman and Davis (2000) reported that combination of soil tillage systems and changes in tillage practice can lead to shift in weed species composition of the agricultural community. Weeding regime affected weed density, biomass, sweetpotato root yield and nearly characters assessed in both locations and seasons. Weeding at 4 or 8 WAP promoted growth and yield of sweetpotato similarly but clearly better at Otobi than at Umudike in both locations and seasons. This could be due to lower weed density and biomass recorded during the critical period of the sweetpotato crop growth at Otobi. The observation was in line with the report of Weaver and Tan (1992) that interference of weed before or after the critical period for weed control will not result in unacceptable reduction in yield of crop. There was pronounced growth depression and yield loss occasioned by observation of least total root yield. This finding agreed with the report of Obadoni and Remison (2006) on significant yield loss due to uncontrolled weed growth and subsequent crop yield reduction. The uniformity of the effect of weeding at either 4 or 8 WAP in sweetpotatoplots, may be an expression of the effectiveness of the tillage practice, as the land was ploughed and harrowed, which help and cut the buried weed and weed seeds and thus reduced weed population and encouraged growth vigour of sweetpotato plant. Besides, the reduced weed infestation also encouraged vigorous growth of the sweetpotato, which spread out to smoother weeds. The canopy-suppressive ability of sweetpotato plant is of critical importance in the design of effective weed management strategies (Olorunmaiye *et al*., 2013). Amongst the tillage practices, ridges and mounds performed better than flat in terms of growth and yield characters of sweetpotato in this study. This is in line with opinion of Udo *et al* (2016), who reported that ridging or surface hoeing significantly increased vine length, number of leaves and final yield of Telfaria over flat treatment in Uyo environment.

The economics of the enterprise in 2017 and 2018 at Otobi showed that ridging, complemented with manual weeding at 8 weeks after planting gave an income of ₦59,400.00 per hectare, while the return per naira investment shows that in every one naira invested in the sweetpotato production, an income of ₦1.19 was realized. At Umudike, ridgingcomplemented with manual weeding at 8 weeks after planting (WAP) gave an income of ₦17,000.00 per hectare and return per naira investment of ₦1.06. The profit realized from Otobi was three times more than the profit realized at Umudike. The reason could be deduced from high cost of production inputs at Umudike.

CONCLUSION/RECOMMENDATION

Planting on ridges resulted to lower weed density and biomass and also highest root yield (18.92 and 15.20 t/ha at Otobi and Umudike, respectively) when compared to other treatments. It is therefore recommended that sweetpotato should be planted on ridges and complemented with manual weeding at 8 WAP for increased yield and income generation.

REFERENCES

Agbo, M. O. and Ene, L. S. O. (1994).*Studies of Sweetpotato Production and Research in Nigeria*. International Potato Centre. Sweetpotato Situation and Priority Research in West and Central Africa.CIP, Lima, Peru.Pp. 124.

Alabi, B. S. (1999), Weed Control and Corn Tolerance from Soil-applied.RPA 201772.Nigeria Journal of Weed Science 13:913-925

Anderson, J. M. and Ingram, J. S. I. (1993). Tropical Soil Biology and Fertility: A handbook of Method of Analysis CAB.International.Wallingford, UK Pp.38-39.

Ball, B. C. and Miller, Y. (1993). Cropping History, Tillage and Herbicides Effects on Weed Flora Composition in Irrigation Corn, Agronomy Journals.85:817-821

Barberi, L. (2001). Bio-efficiency of New Promising Herbicides for Weed Management in Summer Rice.India Journal of Weed Science 32 (1 and 2): 35-38.

Bray, R.A. and Kurtz, L.T. (1945). Determination of Total Organic and Available Forms of Phosphorus in Soils.SoilScience. Pp. 39-45

Bremner, J. M. (1996), Nitrogen-total. In: Sparks, D. I. (Ed.), Methods of Soil Analysis. Part3. Chemical Methods. Second edition, SSSA Book series No.5, ASA and SSSA, Madison, WI, USA, PP: 1085-1121

Bremner, J.M. and Mulvaney, C.S. (1982).Total nitrogrn. In: A.L. Page (Ed.). Methods of Soil Analyses Part II, Agronomy 2nd Edition. No 9. ASA Madison WI.Pp 595 – 624.

Buhler, D. D. (1995).Influenced by Tillage Systems on Weed Population Dynamics and Management in Corn and Soyabean in Central, USA.CropScience 351: 1247-1258.

Carter, M. R. (1993), Soil Sampling and Methods of Analysis. Canadian Society of Soil Science, Lewis publishers, London. Pp. 823.

Collins, W.W. (1995), Newcrop Fact Sheet.http://www.hort.purdue.edu/newcrop/cr opfact sheets/sweetpotato Html.Accessed March, 2006.

Gee, G.W. and Bauder, J.W. (1986). Particle size analysis.Methods of soil analysis. Ed. A. Klute.American Society of Agronomy.Madison, W.I. USA.

Hahn, S. K and Hozyo.Y.(1984), Sweetpotato.In: Goldsworthy, P.R and Fisher, N.M (eds). The physiology of Tropical field crops.John Wiley and sons Ltd. Pp.551-557.

Hatfield, J. C., Allmarass, R.R., Rehm, G.W and Lowery, B. (1999), Ridge Tillage for Corn and Soybean Production and Environmental Quality Impacts.Soil and Tillage Research 48:145-154.

Horton, D. Prain, G. and Gregory, P. (1989).High Level Investment Returns of Global Sweetpotato Research and Development. C.I.P. Circular 17-11. Tropical Root Crops in Developing Economy.Ofori Root Crops.20-26th October, 1991, Accra Ghana. Pp. 89

Lal, R. (1976). Soil Erosion Problem on an Alfisol in Western Nigeria and their Control.IITA Management Series.No.1. Ibadan, Nigeria. Pp:208.

Leibman, M. and Davis, A. S. (2000). Integration of Soil, Crop and Weed Management in Low-external – input Farming Systems. Weed Research 40(1):27-47

Mclean, E. O. (1982). Soil pH and lime requirement. In Page A. L. (ed).Methods of soil analysis. Part 2., 2nd edition. Chemical and microbiological properties, Agronomy Monograph 9,Madison, WI, USA, ASA and SSSA pp 199 – 224.

Melifonwu ,A. A. (1994). Control of Mimosainvisa in Maize (Zeamays L.) with Atrazine Mixture with Alachlor and Metolachlor. Nigeria Journal of Weed Science 8(4):6-9.

Nelson, D.W. and L.E. Sommers, (1982). Total carbon organic carbon and organic matter. In: A.Z. Page et al. (eds.). Methods of soil analysis. Part 2, 2nd ed. ASA, SSSA, pp539-579.

NRCRI (2005),National Root Crops Research Institute Annual Report. Pp 63-65.

Obadoni, B. O. and Remison, S. U. (2006). Effects of Time of Weeding and Rates of Fertilizer Application on the Performance of Upland Rice in Edo States. Nigeria Journal of Sustainable Tropical Agricultural Research 18:115-120

Olorunmaiye, P. M., Lagoke, S. T. O., Adigun, J. A. and Orija, O. R. (2013). Effect of Intercropping with Maize on Weed Density in Cassava, Environmental Experimental Biology 11:189-193.

Olsen, S. R. and Sommers, L. E. (1982).Phosphorus. In: Page, A. L., Miller, R. H. and Keeny, D. R. (Eds).Methods of Soil Analysis. Part II. 2nd ed. Am. Soc. of Agron. Inc., Madison W. I. pp. 15 – 72.

Onwueme, I. C. and Charles, W. B. (1994).Cultivation of Cocoyam. In: Tropical Root and Tuber Crops. Production, Perspectives and Future Prospects. FAO Plant Production and Protection Paper 126, Rome. Pp. 139 – 16

Streibig, J. C. (1988), Weeds. The Pioneer Flora of Arable Land.EcologicalBulletins. 39:59-62.

Tan, K. H. (1996). Soil Sampling, preparation and analysis.Mercel Decker Inc. 270 Madison Avenue, New York. 112pp.

Thomas, G. W. (1982). Exchangeable cation In: Page A.L et al (eds) Method of Soil Analysis. Part 2, Agronomy Monograph, a second edition.American Society of Agronomy and Soil Science Society of American.Pp159-165.

Udealor, A. and Ezulike T.U. (2011).Evaluation of Different Crop Species for Compatibility with Cocoyam Miniset. The Nigeria Agricultural Journal 42:122-129.

Udo, E. I., Ndaeyo, N. U. and Ike, A. O. (2016). Yield Productivity of Telfairis Occidentialis and Economic Return to Management as Influenced by Tillage Practices in Uyo, South Eastern Nigeria. Journal of Forestry, Environment and Sustainable Development.Vol. 2 No. 2 pp. 92 – 101.

Unamma, R. P. A. (1981), Investigation of Weed Interference in White Yam (Dioscorearotundatapoir). Ph.D. Thesis, University of Ibadan. 235p.

Weaver, S. E. and Tan, C. T. (1992).Critical period of weed interference in transplanted tomatoes (Lycopersiconesculentum) growth analysis.Weed Science 31:476-481.

Wilson, R. G. (1988). Biology of Weed Seeds in the Soil.In Weed Management in Agro-ecosystems.Ecological Approaches (Eds.), M.A, Altier and M. Liebman.Buca Raton, FL: C. K. C. Press. Pp.25-39.