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Weed Biomass and Weed Species Diversity of Juvenile Citrus Trees Intercrop with some Arable Crops

Patience Mojibade OLORUNMAIYE[1*], Stephen Olaoye AFOLAYAN[2]

[1]*University of Agriculture Abeokuta, Department of Plant Physiology and Crop Production, Abeokuta, Nigeria; pmmoji@yahoo.co.uk (*corresponding author)*

[2]*National Horticultural Research Institute, Bagauda Substation, Kano, Nigeria*

Abstract

A preliminary study was carried out to evaluate the performances of eight crops in the intercrop of citrus with arable crops at the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria. Eight arable crops: maize, cucumber, sweet potato, *Corchorus olitorius*, large green, grain amaranth, *Mucuna pruriens* var. *utilis*, and groundnut were intercropped with young citrus trees in the early planting season of 2010 with sole citrus as control. The experiment was laid out in a completely randomized block design with three replicates. Data were collected on weed flora, weed density and weed dry weight. Results showed that the relative frequencies of weeds in all the plots were less than 4% at both 6 and 9 WAP. G*omphrena celosoides, Oldenlandia corymbosa* and *Tridax procumbens* were most preponderant in appearing in all the plots. *Tridax procumbens* had a consistent relative frequency (2.34%) in all the plots except in citrus/maize plot (0.78%) at 9 WAP. Significantly lower broadleaf weed densities were obtained in citrus/sweet potato, citrus/large green, control plot and citrus/cucumber (28.67, 45.00, 50.00 and 76.33 m^{-2} respectively) than in citrus/groundnut plot (143.00 m^{-2}). Similarly, significantly lower grass weed densities were produced in citrus/*Mucuna* and citrus/sweet potato (0.33 m^{-2} each) plots than the control plot (11.33 m^{-2}). Whereas citrus/*Corchorus* plot produced significantly lower broadleaf weed dry weight (37.59 g m^{-2}) than citrus/*Mucuna* plot (126.47 g m^{-2}) at 3 WAP, citrus/large green plot (16.15 g m^{-2}) and citrus/groundnut plot (123.25 g m^{-2}) followed the same trend at 6 WAP. Sedges dry weights were less than 7 g m^{-2} in all the plots compared with control plot.

Keywords: weed density, relative frequency, *Mucuna pruriens*, large green, grain amaranth, cucumber

Introduction

Citrus as a fruit crop acts as a rich source of vitamin C and other essential nutrients required by human body and this has necessitated its wide cultivation in Nigeria (Adewale *et al*., 1996), Brazil, USA and other countries (Florida Citrus Agriculture, 2004). The citrus trees take longer time to produce fruit and so short duration crops like chilli, amaranth (Aiyelaagbe, 2001), turmeric, pepper, ginger and basil (Oyedele *et al*., 2011) can provide ready cash flow. In the southern part of Nigeria, a number of crops like cowpea, okra, water melon, pepper, amaranth and maize have been found to be compatible with citrus intercrop (NIHORT, 2000). Intercropping is the cultivation of two or more crops at the same time in the same field. Its profits are risk minimization, increase in farmers' income and food security, reduction of soil erosion, pest and disease control (Bekunda, 1999; Bekunda and Woomer, 1996; Jodha, 1979; Owuor *et al.*, 2002). Depending on the crops intercropped, competition for water, light and nutrients may result in lower yields. Lower weed biomass has been reported in intercropping systems where a main crop was inter-sown with a "smother" crop species (Jodha, 1979). Greater crop yield and less weed growth can be obtained more frequently in intercrops than in sole crops. In East Africa fruit crops are usually intercropped with annual crops for example, banana is intercropped with food and / or fodder crops (Clark and Francis, 1985) while in India bananas are intercropped with potato which had resulted in good returns (Okigbo, 1979). An intercrop between citrus mandarin seedlings and cucumber has also been reported to give high yield of cucumber fruit and minimal interference in the growth of citrus seedlings which might be due to the low growing nature of the latter (Natarajaa and Nairk, 1992). In Kenya, fruit trees are intercropped with all types of short term crops such as beans, peas, potatoes, maize, millet, exotic and indigenous vegetables when they are still young as a way of attaining food security and income before the trees mature. Intercropping can be used as an effective weed control strategy (George and Jeruto, 2010) as different plant types growing together enhances weed control by increasing shade and crop competition with weeds through tighter crop spacing. Data on the weed biomass and weed flora diversity in juvenile citrus intercrop with arable crops at the National Horticultural Research Institute, Ibadan, a south-west forest ecological zone of Nigeria has not been documented. It is therefore the objective of this study to investigate the weed biomass, weed density and weed species diversity of a citrus intercrop with some arable crops.

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Materials and methods

The study was conducted at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria in the early cropping season of 2010. The treatments comprised of 8 arable crops [maize (var. 'DMR LSR' yellow)], cucumber (royal hybrid F1), sweet potato, *Corchorus olitorius,* large green, grain amaranth, *Mucuna pruriens* var. *utilis* and groundnut) with a citrus plot without any crop as control. The arable crops were intercropped with the young citrus trees of about 3 years old. Land preparation was done manually by slashing with cutlass in late April, 2010 and the experiment was laid in a completely randomized block design with three replicates. The size of each plot was 6 m × 12 m. Maize and *M. pruriens* were planted at a spacing of 90 cm × 45 cm each, cucumber, groundnut and sweet potato at 60 cm × 30 cm each while *Corchorus* , large green, and grain amaranth were drilled at 30 cm apart each at a

Tab. 1. Weed species composition of intercropping citrus with arable crops in NIHORT, Ibadan Nigeria

Weed species	Growth form	Families
Acroceras zizanoides Dandy	PG	*Poaceae*
Ageratum conyzoides L.	ABL	*Asteraceae*
Alternanthera sessilis (L.) R. Br. Ex Roth	ABL	*Amaranthaceae*
Amaranthus viridus	ABL	*Amaranthaceae*
Aspilia africana (Pers.)c. Adams	ABL	*Asteraceae*
Axonopus compressus (Sw.) P. Beauv.	AG	*Poaceae*
Boerhavia diffusa L.	ABL	*Nyctaginaceae*
Celosia spp.	ABL	*Amaranthaceae*
Centrosema pubescens Benth.	PBL	*Fabaceae*
Cleome viscossa	ABL	*Cleomaceae*
Commelina benghalensis L.	ABL	*Commelinaceae*
Commelina erecta L.	ABL	*Commelinaceae*
Corchorus olitorious L	ABL	*Tiliaceae*
Cyperus esculentus Linn.	PS	*Cyperaceae*
Cynodon dactylon	PG	*Poaceae*
Desmodium scropiurus (Sw.) Desv.	ABL	*Fabaceae*
Digitaria horizontalis	AG	*Poaceae*
Euphorbia heterophylla L.	ABL	*Euphorbiaceae*
Euphorbia hirta L.	ABL	*Euphorbiaceae*
Gomphrena celosoides Mart.	ABL	*Amaranthaceae*
Ipomoea bartatas	ABL	*Convolvulaceae*
Ipomoea triloba Linn.	ABL	*Convolvulaceae*
Larpotea aestuans (Linn.) Chew.	ABL	*Urticaceae*
Leptochloa caerulescens	AG	*Poaceae*
Mariscus alternifolius Vahl	PS	*Cyperaceae*
Mitracarpus villosus (SW) DC	ABL	*Rubiaceae*
Oldenladia corymbosa (Linn.)Roxb.	ABL	*Rubiaceae*
Panicum maximum Jacq. O. Ktze	AG	*Poaceae*
Paspalum obiculare Forst.	AG	*Poaceae*
Paspalum conjugatum Berg	AG	*Poaceae*
Peperomia pellucida Linn	ABL	*Piperaceae*
Phillanthus amarus Schum, et Thonn.	ABL	*Euphorbiaceae*
Platostoma africanum P. Beauv.	ABL	*Lamiaceae*
Portulaca oleracea Linn.	ABL	*Portulaceae*
Physalis angulata Linn.	ABL	*Solanaceae*
Setaria barbata (Lam.) Kunth.	AG	*Poaceae*
Setaria longiseta	AG	*Poaceae*
Senna spp.	ABL	*Caesalpiniaceae*
Synedrella nodiflora Gaertn.	ABL	*Asteraceae*
Talinum triangulare (Jacq.) Willd.	PBL	*Portulaceae*
Tridax procumbens L.	ABL	*Asteraceae*
Waltheria indica L.	PBL	*Sterculiaceae*

Note: AG = Annual Grass; PBL = Perennial Broadleaf; PG = Perennial Grass; PS = Perennial Sedge; ABL = Annual Broadleaf

seed rate of 6 kg ha^{-1} between 29 April and 13 May. All the crops were planted at 1 m away from the base of the young citrus trees. Hoe weeding was done 2 times. Data were collected on weed density, weed dry weight and weed flora at 3, 6 and 9 WAP with the use of two 0.5 m × 0.5 m quadrate which were permanently placed randomly within each plot. Weeds within each quadrate were uprooted, sorted into broadleaves, grasses and sedges, identified, counted, and recorded to compute weed density. The weeds were then oven dried for 48 hours at 80°C and weighed to compute weed dry weight. Data on weed density and weed dry weight were subjected to analysis of variance using Genstat package while ecological analysis of the weed flora was carried out to determine the weeds relative frequencies.

Results

Relative frequencies of weeds

A total of 42 weed species belonging to 19 families were encountered in the course of this study (Tab. 1). Poaceae family had 10 species, *Amaranthaceae* and *Asteraceae* had 4 each, *Euphorbiaceae* 3, *Commelinaceae, Convolvulaceae, Cyperaceae, Fabaceae, Portulaceae* and Rubiaceae had 2 each while *Caesalpinaceae, Cleomaceae, Lamiaceae, Piperaceae, Tiliaceae*, *Solanaceae, Sterculiaceae Urticaceae* and *Nyctaginaceae* had 1 species each. There were 30 broadleaf weed species, 10 grasses and 2 sedges. At 6 WAP, citrus/*Corchorus* plot had the highest number of weed species (19) followed by groundnut plot (17), citrus plots inter-

Tab. 2. Weed relative frequencies (%) in young citrus trees intercropped with arable crops 6 WAP at NIHORT, Ibadan, Nigeria

Weed species	Relative frequency (%) 6 WAP								
	MA	CU	SP	CO	LG	GA	MU	GN	C
Acroceras zizanoides Dandy	-	-	-	0.46	-	-	-	-	-
Ageratum conyzoides L.	0.46	0.92	0.46	0.92	0.46	0.46	-	0.46	0.46
Alternanthera sessilis	0.92	0.46	0.92	0.46	0.46	-	-	0.92	0.46
Amaranthus viridus	-	-	0.92	-	0.46	1.38	0.46	0.46	-
Aspilia africana (Pers.) c. Adams	-	-	-	-	-	0.46	-	-	-
Axonopus compressus (Sw.) P. Beauv.	-	0.46	-	-	0.46	-	-	-	-
Boerhavia diffusa L.	-	-	-	0.46	-	0.46	-	-	-
Centrosema pubescens Benth.	-	-							
Commelina benghalensis L.	0.92	0.46	0.46	-	-	0.46	-	0.46	1.38
Corchorus olitorious Linn.	0.92	0.46	-	0.92	0.92	-	0.92	0.46	-
Cyperus esculentus Linn.	0.46	0.92	-	-	-	-	-	0.46	0.46
Desmodium scropiurus (Sw.) Desv.	0.46	-	-	-	-	-	0.46	0.46	0.46
Euphorbia heterophylla Linn.	-	0.46	0.46	-	-	-	0.46	0.46	-
Euphorbia hirta Linn.	0.46	0.46	-	0.46	-	0.46	0.46	-	-
Gomphrena celosoides Mart.	0.92	1.38							
Ipomoea triloba Linn.	-	0.46	0.46	-	-	-	-	-	-
Larpotea aestuans (Linn.) Chew.	-	-	-	0.92	-	0.92	-	-	-
Leptochloa caerulescens Steud	-	-	-	0.92	1.38	1.38	0.46	0.92	0.92
Mariscus alternifolius Vahl	-0.46	1.38	-	0.92	0.46	0.92	1.38	1.38	1.38
Mitracarpus villosus (SW) DC	-	-	0.46	0.46	0.92-	-	-	-	-
Oldenladia corymbosa (Linn.)Roxb.	-	-	-	0.46	0.92	0.92	-	-	-
Panicum maximum Jacq. O. Ktze	-	-	-	-	-	-	-	0.46	-
Peperomia pellucida (L.) H. B. & K.	-	-	-	-	0.92	-	-	-	-
Phillanthus amarus Schum, et Thonn.	-	-	-	0.46	0.46	0.46	-	-	-
Portulaca oleracea Linn.	-	-	-	0.46	-	-	-	-	-
Physalis angulata Linn.	-	-	-	0.46	-	-	-	-	-
Senna spp.	-	-	-	-	-	-	-	0.46	-
Setaria barbata (Lam.) Kunth.	-	0.46	-	0.92	0.46	-	-	1.38	0.92
Sida cordifolia Linn.	-	-	-	-	-	-	-	-	0.46
Spigelia anthelmia Linn.	-	0.46	0.46	0.46	0.46	0.38	0.46	0.92	-
Synedrella nodiflora Gaertn.	-	-	0.92	0.46	-	0.46	-	0.46	-
Talinum triangulare (Jacq.) Willd.	1.38	1.38	1.38	0.92	0.92	0.46	0.46	1.38	1.38
Tridax procumbens L.	1.38	1.38	1.38	0.92	0.92	1.38	1.38	0.92	0.92
Total number of weed species	11	15	11	19	15	15	10	17	11

Note: MA = Maize; CU = Cucumber; SP = Sweet Potato; CO = *Corchorus*; LG = Large Green; GA = Grain Amaranth; MU = *Mucuna pruriens* var. *utilis*; GN = Groundnut; C = Control

cropped with cucumber, large green and grain amaranth had 15 weed species each, citrus/maize, citrus/sweet potato and control plots had 11 weed species each while citrus/*Mucuna* plot had 10 (Tab. 2). Two weed species: *Talinum triangulare* and *Tridax procumbens* associated with all the crops. Whereas *T. triangulare* had a consistent relative frequency of 1.38% in citrus/maize, citrus/cucumber, citrus/sweet potato, citrus/groundnut and control plots, *T. procumbens* had the same trend in citrus/maize, citrus/cucumber, citrus/sweet potato, citrus/large green and citrus/grain amaranth plots at 6 WAP (Tab. 2). At 9 WAP, citrus plots intercropped with large green and cucumber recorded 16 weed species each, citrus/maize had 15 weed species, citrus/sweet potato and citrus/*Mucuna* plots had 14 weed species each, citrus/large green and citrus/groundnut plots recorded 12 weed species each while the control plot followed the same trend as in 6 WAP (Tab. 3). The relative frequencies of weeds in all the plots were less than 4% at both 6 and 9 WAP (Tab. 2 and 3) and at 9 WAP, three weed species: *G. celosoides, O. corymbosa* and *T. procumbens* appeared in all the plots. *Tridax procumbens* had a consistent relative frequency of 2.34% in all the plots except in maize plot (0.78%) as shown in Tab. 3.

Tab. 3. Weed Relative Frequencies (%) in young citrus trees intercropped with arable crops 9 WAP at NIHORT, Ibadan, Nigeria

Weed species	Relative Frequency (%) 9 WAP								
	MA	CU	SP	CO	LG	GA	MU	GN	C
Acroceras zizanoides Dandy	-	0.78	-	-	-	-	-	-	-
Ageratum conyzoides L.	0.78	0.78	-	2.34	2.34	0.78	2.34	-	0.78
Alternanthera sessilis (L.) R. ex Roth	-	1.56	1.56	-	1.56	-	1.56	0.78	1.56
Amaranthus viridus	0.78	0.78	0.78	-	-	-	-	-	-
Aspilia africana (Pers.) c. Adams	-	0.78	-	-	-	-	-	-	-
Boerhavia diffusa L.	-	-	0.78	-	0.78	-	0.78	0.78	-
Celosia laxa Schum and Thonn.	-	-	0.78	-	-	-	-	-	-
Centrosema pubescens Benth.	-	-	-	-	-	0.78	-	-	-
Cleome viscossa L.	-	-	-	-	0.78	0.78	-	-	-
Commelina benghalensis L.	-	-	-	0.78	-	-	-	-	-
Commelina erecta L.	-	-	-	-	-	-	-	0.78	-
Corchorus olitorious L.	0.78	0.78	-	0.78	1.56	0.78	0.78	-	-
Cyperus esculentus Linn.	0.78	-	0.78	-	-	1.56	-	0.78	1.56
Cynodon dactylon (Linn.) Pers.	-	0.78	-	-	0.78	-	0.78	-	0.78
Desmodium scropiurus (Sw.) Desv.	-	-	-	-	0.78	-	-	-	-
Digitaria horizontalis Willd	-	0.78	-	-	-	-	0.78	-	-
Euphorbia heterophylla L.	-	0.78	-	-	-	-	-	-	-
Gomphrena celosoides Mart.	0.78	0.78	1.56	2.34	0.78	2.34	2.34	1.56	0.78
Ipomoea bartatas	-	-	-	-	-	-	-	-	0.78
Ipomoea triloba Linn.	-	-	0.78	-	-	-	-	-	-
Lapartea aestuans (Linn.) Chew.	0.78	-	0.78	-	0.78	-	-	-	0.78
Leptochloa caerulescens Steud.	0.78	0.78	0.78	-	-	-	-	-	-
Mariscus alternifolius Vahl	0.78	1.56	0.78	0.78	0.78	-	1.56	-	-
Mitracarpus villosus (SW) DC	0.78	2.34	-	1.56	1.56	0.78	-	-	-
Oldenladia corymbosa (Linn.)Roxb.	0.78	1.56	0.78	2.34	0.78	1.56	0.78	0.78	0.78
Panicum maximum Jacq. O. Ktze	-	-	-	-	-	-	0.78	-	-
Paspalum obiculare Forst.	-	-	-	-	-	-	-	-	0.78
Paspalum conjugatum Berg.	0.78	-	-	-	-	-	-	-	-
Peperomia pellucida (L.) H. B. & K.	0.78	-	-	-	-	-	-	-	-
Phillanthus amarus Schum, et Thonn.	-	-	-	-	-	0.78	-	-	-
Platostoma africanum P. Beauv.	-	-	-	-	-	-	-	0.78	-
Portulaca oleracea Linn.	-	-	-	-	-	-	-	0.78	-
Physalis angulata Linn.	-	-	-	-	0.78	-	-	-	-
Setaria barbata (Lam.) Kunth.	0.78	0.78	-	-	1.56	-	-	0.78	0.78
Setaria longiseta P. Beauv.	-	-	-	0.78	-	-	0.78	-	-
Synedrella nodiflora Gaertn.	-	-	0.78	0.78	0.78	1.56	1.56	-	-
Talinum triangulare (Jacq.) Willd.	0.78	-	1.56	-	-	0.78	1.56	0.78	1.56
Tridax procumbens L.	0.78	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34
Waltheria indica Linn.	-	-	-	-	-	-	-	0.78	-
Total number of weed species	15	16	14	10	16	12	14	12	11

Note: MA = Maize; CU = Cucumber; SP = Sweet Potato; CO = *Corchorus*; LG = Large Green; GA = Grain Amaranth; MU = *Mucuna pruriens* (var. utilis); GN = Groundnut; C = Control

Broadleaf weed density

Broadleaf weed density was not significantly affected at 3 WAP (Tab. 4), however, at 6 WAP, significantly lower broadleaf weed densities were obtained in citrus/sweet potato, citrus/large green, control (sole citrus) and citrus/cucumber plots (28.67, 45.00, 50.00 and 76.33 weeds m^{-2} respectively). All these were significantly higher than what was obtained in citrus/groundnut plot (143.00 weeds m^{-2}). Citrus plots containing cucumber (20.67 weeds m^{-2}) and sweet potato (21.00 weeds m^{-2}) produced lower broadleaf weed densities at 9 WAP compared to control plot (26.33 weeds m^{-2}), however, this effect was not significant.

Grass weed density

Grass weed density was generally low in all the citrus plots planted to these arable crops at all the periods of enumeration (Tab. 4). At 3 WAP, citrus/cucumber plot produced the lowest grass weed density (3.00 weeds m^{-2}) while citrus/maize plot produced the highest grass weed density (15.67 weeds m^{-2}) however, these means were not statistically significant. At 6 WAP, significantly lower grass weed densities were produced in citrus plots containing *Mucuna* and sweet potato (0.33 m^{-2} each) than the control plot (11.33 m^{-2}) and at 9 WAP, while citrus/cucumber plot produced grass weed density that was at par with control plot (3.00 m^{-2}), citrus/grain amaranth plot had no grass weed recorded.

Sedge weed density

Sedge weed density was not significant in all the periods of enumeration however, at 3 WAP, citrus/grain amaranth plot produced the lowest sedge weed density (1.67 weeds m^{-2}) while the highest was obtained in cucumber plot (9.00 weeds m^{-2}) (Tab. 4). At 6 WAP, citrus/sweet potato plot had no sedge weed at all while the control plot produced the highest (18.00 weeds m^{-2}) and at 9 WAP, citrus/C*orchorus* plot produced the lowest sedge weed density (0.33 weeds m^{-2}) and the highest value was obtained in the citrus plot containing grain/amaranth (5.00 weeds m^{-2}).

Tab. 4. Effect of intercropping young citrus trees with arable crops on weed density (no m^{-2}) at NIHORT, Nigeria

Treatments	Weed density (no m^{-2})								
	Broadleaf weeds			Grass weeds			Sedges		
	3 WAP	6 WAP	9 WAP	3 WAP	6 WAP	9 WAP	3 WAP	6 WAP	9 WAP
Citrus/MA	64.00	96.67ab	87.00	15.67	3.33bc	1.67	5.00	4.00	4.33
Citrus/GN	90.00	143.00a	36.67	10.67	8.00ab	0.33	4.52	13.33	1.33
Citrus/CU	75.33	76.33b	20.67	3.00	1.33bc	3.00	9.00	2.33	4.33
Citrus/LG	98.33	45.00b	103.00	10.00	4.33abc	2.00	5.67	0.67	1.67
Citrus/SP	93.67	28.67b	21.00	8.00	0.33c	2.33	2.67	0.00	1.67
Citrus/GA	135.67	168.68ab	49.67	13.67	4.67abc	0.00	1.67	17.67	5.00
Citrus/MU	59.67	86.00ab	46.33	11.33	0.33c	2.67	4.33	1.33	1.33
Citrus/CO	103.33	104.33ab	25.67	13.00	7.33abc	0.67	3.33	10.33	0.33
Control	90.00	50.00b	26.33	10.67	11.33a	3.00	4.52	18.00	2.33
S.E.D.	33.86	60.00	35.01	8.36	3.15	1.85	3.88	7.98	2.32
	ns		ns	ns		ns	ns	ns	ns

Note: MA = Maize; SP = Sweet Potato; GN = Groundnut; GA = Grain Amaranth; CU = Cucumber; *Mucunapruriens* (var. *utilis*); LG = Large Green *Corchorusolitorius*; WAP = Weeks after planting

Tab. 5. Effect of intercropping young citrus trees with arable crops on weed dry weight (g m^{-2}) in NIHORT, Ibadan, Nigeria

Treatments	Weed dry weight (g m^{-2})							
	Broadleaf weeds			Grass weeds			Sedges	
	3 WAP	6 WAP	9 WAP	3 WAP	6 WAP	9 WAP	3 WAP	6 WAP
Citrus/MA	92.98ab	44.44bc	64.58	76.74a	3.57	4.17	10.71	6.22b
Citrus/GN	83.08ab	123.25a	58.80	17.40ab	44.56	0.82	7.72	60.64ab
Citrus/CU	119.18a	72.57ab	77.39	7.62b	0.00	4.29	23.98	2.60b
Citrus/LG	72.12ab	16.51c	66.86	4.84b	7.22	6.15	5.29	1.55b
Citrus/SP	85.52ab	34.82bc	28.44	18.22ab	0.00	0.85	7.51	0.00b
Citrus/GA	45.72b	70.70ab	48.47	1.68b	1.53	0.00	0.00	2.02b
Citrus/MU	126.47a	52.83b	37.06	3.14b	0.14	3.20	5.27	0.73b
Citrus/CO	37.59b	53.36b	30.02	9.56b	3.59	1.07	1.63	4.86b
Control	83.08ab	62.26b	18.77	17.40ab	27.53	0.00	7.77	64.63a
S.E.D.	28.21	37.91	26.95	25.52	7.10	2.81	10.04	26.06
			ns		ns	ns	ns	

Note: MA = Maize; SP = Sweet Potato; GN = Groundnut; GA = Grain Amaranth; CU = Cucumber *Mucunapruriens* (var. *utilis*); LG = Large Green *Corchorusolitorius*; WAP = Weeks after planting

Broadleaf weed dry weight

The various periods of enumeration of dry weed density were shown in Tab. 5. Citrus plot intercropped with *Corchorus* produced significantly lower dry weight (37.59 g m^{-2}) than the citrus plots containing *Mucuna* (126.47 g m^{-2}) at 3 WAP. Also significant effect was observed at 6 WAP where citrus/large green plots produced significantly lower broadleaf weed dry weight (16.15 g m^{-2}) than citrus/groundnut plot (123.25 g m^{-2}) while there were no significant effects at 9 WAP.

Grass weed dry weight

Grass weed dry weight was significantly lower in the citrus plots containing grain amaranth, *Mucuna pruriens*, large green, cucumber and *Corchorus* (1.68, 3.14, 4.84, 7.62 and 9.56 g m^{-2} respectively) than citrus/maize intercrop (76.74 g m^{-2}) at 3 WAP (Tab. 5). Citrus/cucumber and citrus/sweet potato plots at 6 WAP and citrus/grain amaranth and control plots at 9 WAP recorded 0.0g m^{-2} grass weed dry weight compared to citrus/groundnut plot at 6 WAP and citrus/large green plots at 9 WAP (44.56 and 6.51 g m^{-2} respectively).

Sedge weed dry weight

Sedge dry weight was only significant at 6 WAP where sedge dry weights were less than 7 g m^{-2} in all the plots compared with control plot (64.63 g m^{-2}) (Tab. 5) while there was no sedge in none of the plots at 9 WAP.

Discussion

The intercropping of young citrus trees with arable crops presented variable effects on weed parameters. The experimental site was infested with three different types of weeds which were broadleaf weeds, grass weeds and sedges. Broad leaf weeds comprising of 30 species accounted for 71.43% of the infestation followed by grass weed comprising of 10 species with 23.80% while sedges with only two species had the lowest (4.76%). This high weed incidence may be attributed to the manual weed control method employed in the citrus orchard for about three years which is only effective before weeds produce flowers. In addition, the young citrus trees received moisture through drip irrigation in the dry season which some of these weeds might have taken advantage of for growth and development. The rate of occurrence of the weed species under the various treatments was less than 5%, however, three weed species: *G. celosoides, O. corymbosa* and *T. procumbens* associated with all the intercrops except that of maize at 9 WAP and the consistent occurrence of *T. procumbens* with higher relative frequency (2.34%) than the other two species is an indication of future dominance. This weed produces roots at the lower nodes and reproduces from seeds with an effective seed dispersal agent which will greatly affect its density in the future. Intercropping citrus with sweet potato, cucumber and large green significantly reduced broadleaf weed density compared to citrus/groundnut plot while the same trend was observed for grass weed density in the citrus plots containing sweet potato and *M. pruriens* var *utilis* than that obtained in the control plot. Similarly, both citrus/*Mucuna* and citrus/sweet potato plots produced significantly lower grass weed dry weight than the control plot at 6 WAP. This result agrees with the earlier reports of Jodha (1979) and George and Jeruto (2010).

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