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EFFECTS OF FERTILIZER TYPE AND CROPPING SYSTEM ON GROWTH AND DRY MATTER YIELD OF PHYSIC NUT (*Jatropha curcas* L.) IN THE RAINFOREST AGRO-ECOLOGY OF NIGERIA

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ABSTRACT

Productivity of crops depends largely on the suitability of soil environment in supplying the needed resources for growth and the competitive capacity of the component plants. A field experiment was conducted during the growing seasons of 2019 and 2020 at Ikenne and Ibadan, Southwest Nigeria to assess the effects of fertilizer type and cropping system on the growth and dry matter yield of Jatropha. The experiment was a split-plot arrangement in a Randomized Complete Block design, replicated three times. Fertilizer types (NPK; Organic; Organic + NPK (50:50) and control were the main plots while cropping systems of sole okra; sole Jatropha and Jatropha/okra intercrop were sub-plots. Data collected to determine Jatropha growth include plant height, number of leaves/plant, canopy width and dry matter yield. At Ikenne, organic fertilizer consistently produced more leaves (209) followed by organic + NPK (134) and the least from the control plant (87). Tallest plant was from organic (181.2 cm) followed by organic + NPK treatment (176.2 cm) as well as highest canopy width of 169.8 cm from organic followed by 130.9 cm from organic + NPK. At Ibadan, all the fertilizer sources had comparable effects on jatropha growth but were significantly higher than control plant. Growth of Jatropha expressed as canopy width, number of leaves/plant and plant height had similar values either as a sole crop or as intercrop. Jatropha had similar number of leaves/plant as a sole crop (31) and in intercrop (26) with okra at Ikenne. Similar trend was observed at Ibadan where at 56 WAS, sole jatropha produced 47 leaves which was similar with 33 from the intercrop. Similarly, in both locations, cropping system did not have significant effect on plant height and canopy width, indicating the compatibility of both crops at both sites. Dry matter yield was not affected by cropping system but was improved by fertilizer application. With higher root dry weight of between 5 and 35 % than the shoot dry weight, Jatropha was able to establish better via improved water and nutrient absorption resulting in proper plant establishment against possible soil erosion. Inclusion of Jatropha into cropping system in the rainforest zone and application of organic fertilizer, is therefore recommended.

Keywords: Cropping system; Dry matter; Fertilizer; Jatropha

INTRODUCTION

Jatropha or Physic nut, (*Jatropha curcas* L.) is one of the important oil seed crops belonging to the *Euphorbiaceae* family, same as rubber tree and cassava (Gubitz *et al*., 1999). The plant is known as Lapalapa in Yoruba, Wuluidu in Igbo and Cini da zugu in Hausa. Jatropha seeds can be processed into lesser polluting biodiesel than fossil diesel to provide light and cooking fuel for poor rural families. Seed cake, a by-product from this process may be valuable as fertilizer and animal feed after detoxification. Unlike other major biofuel crops, such as maize, cassava, Jatropha is not used for food and it can be grown on marginal and degraded lands where food crops cannot grow. It is cultivated in central and south America, Southeast Asia, India and Africa (Gübitz *et al*., 1999). Most agricultural food crops require high-quality agricultural land for growth which is scarcely available in Nigeria because of misuse and a disregard for sustainable agriculture like agroforestry and intercropping (Openshaw, 2000). Intercropping, a major component of cropping system, is a system of managing two or more economic species grown together for at least a portion of the life cycle of the component crops and thus experience inter-specific competition among themselves (Usman, 2001; Lithourgidis *et al*., 2011). It plays major roles in peasant food production in both advanced and emerging countries (Adeoye *et al.,* 2005). It tends to give higher yields than sole cropping, greater yield stability and efficient use of mineral resources (Seran and Brintha, 2009; Odedina *et al*., 2014). Agroforestry, a form of intercropping, is an age-old agricultural system practiced in various parts of tropical Asia and Africa. The concept is aimed at overall management of land by combining trees/shrubs with arable crops to control soil erosion, improve soil conditions and conserve soil and water to meet crops needs and the general populace at minimal cost (Adesina *et al*., 1999). Prominent among such trees is Jatropha which has been identified to deliver benefits through both small and large-scale cultivations (Gilbert, 2011). Early publications have noted its potential for degraded land regeneration, as it does not compete substantially with arable crops for nutrients and thus reduces the cost of production, prevents erosion as well as energy provision (Openshaw, 2000). Over the years, fossil fuels supply most of the energy requirements of industrialized nations, which has contributed majorly to greenhouse gas (GHG) emissions that threaten to seriously affect ecosystems through human-induced climate change, which compromises survival of humanity (Cotula *et al.,* 2008). Jatropha, a non-food perennial shrub which is well adapted to semi-arid regions, can serve as a new alternative for biofuel production, minimizing adverse effects on the environment and food supply (Caroline *et al*., 2009). To achieve success in an intensive cropping like intercropping, the challenge of limited resources needs to be addressed headlong. Some of the major constraints identified to be responsible for low production of arable crops include poor soil fertility, high cost and unavailability of inorganic fertilizers, difficulty in getting enough quantity for large scale production (Olawuyi *et al*., 2010). Consequently, use of fertilizers to sustain cropping systems on most tropical soils is necessary due to their low nutrient status (Adetunji, 1991; Adewole and Ilesanmi, 2011). To verify the suitability of cultivating Jatropha in an intercrop without appreciable reduction in its performance, this study was conducted with the objective of assessing the effects of fertilizer sources on Jatropha growth and dry matter yield as a sole crop and in intercrop.

MATERIALS AND METHODS

Site description

Field trials were conducted between July

2019 and November 2020 at the Institute of Agricultural Research and Training (I.A.R&T) stations, Ibadan and Ikenne, Southwestern Nigeria. I.A.R&T Ibadan is in the Transitional vegetation zone of Nigeria on Latitude 07^0 23'N, Longitude 03^0 50'E; 160 m above sea level while Ikenne is in Rainforest belt, and it lies within latitude 6^{o}N and 8^{o}N and longitude 2^{o}E and 5^{o}E.

Soil sampling and analysis.

Eight randomly selected core samples were obtained from 0-15cm soil depth using soil Auger over the experimental site, collated samples were bulked, and a composite sample obtained. The soil samples were air-dried, crushed, and passed through a 2 mm sieve for physical and chemical soil analysis before sowing. At Ibadan, the soil was strongly acidic with pH of 4.67 but 5.48 at Ikenne while the textural class of the soils in both sites was loamy sand (Table 1). Total Nitrogen was low (0.3 and 0.6 g/kg) as they were below the critical level of 1.6-2.0 g/kg (FFD, 2012). Organic carbon was also low (1.7 and 3.8), relative to the critical level of 10-14 g/kg while available phosphorus content was moderate, falling within the critical level of 7- 20 mg/kg (FFD, 2012). The K status of the soil used at both Ibadan and Ikenne were low (0.11 and 0.17 respectively), coming below the critical level of 0.31c mol/kg (FFD, 2012). Both sites are therefore expected to show good response to fertilizer application. However, compost was slightly alkaline, with higher amounts of N, K and organic C with respect to the soil but lower value of P (Table 1).

Table 1: Pre-cropping soil analysis and Compost nutrient composition

Properties	Ibadan	Ikenne	Compost
pH(H_20)(1:1)	4.67	5.48	8.30
Total N (g/kg)	0.3	0.6	2.90
Organic matter (g/kg)	2.92	6.54	129.86
Organic C (g/kg)	1.7	3.8	75.50
Available P (mg/kg)	18.36	13.64	0.42
Exchangeable Bases (cmol/kg)			(g/kg)
Ca	4.86	6.43	55.9
Mg	4.55	1.54	14.2
K	0.11	0.17	18.5
Na	0.46	0.48	3.8
Al+H	0.14	0.12	ND
ECEC	10.12	8.74	ND
Base Saturation (%)	98.62	98.63	ND
Micronutrients (mg/Kg)			
Mn	30.60	22.65	497.00
Fe	3.00	1.25	662.00
Cu	0.50	0.91	25.20
Zn	2.03	1.84	68.71
Particle size (g/kg)			
Sand	938.0	938.0	ND
Silt	14.0	14.0	ND
Clay	48.0	48.0	ND
Textural class	Loamy sand	Loamy sand	ND

ND: not determined

Crop arrangement and experimental design: *Jatropha curcas var Linnaeus* seeds were obtained from the Forestry Research Institute of Nigeria (FRIN) and Okra seeds (LD 88), spineless, late maturing cultivar were sourced from the National Institute for Horticultural Research and Training (NIHORT), Ibadan, Nigeria. Organic compost was made from cassava peel and poultry waste at ratio 2:1; NPK (20:10:10) fertilizer was sourced from farmers market in Ibadan. The experiment was a split-plot arrangement in a Randomized Complete Block design with 12 treatment combinations, replicated three times. Fertilizer type was the main plot while the cropping system was sub-plot. The treatments consisted of four fertilizer sources (applied at the rate of 75 kgN/ha) sourced from NPK, Organic, Organic + NPK (50:50), with no fertilizer as control and three cropping systems comprising of sole okra, sole Jatropha and okra intercropped with Jatropha. Jatropha hedges were established by direct seeding at the onset of the rainy season at a spacing of 2.5 x 1.2 m in the sub plot of 7.5 x 3.6 m, giving 16 plants/plot. Okra was planted eight weeks after Jatropha establishment at the spacing of 30 x 50 cm (NIHORT, 1985) in the sole and in the alleys (2.5 x 1.2 m) of Jatropha where okra was planted, 3 seeds/ hole, at a depth of 2-3 cm and thinned to one plant per stand 2 weeks after planting (WAP). Okra was grown as a sole crop and in the alleys of Jatropha, in the late seasons (September/October) of 2019 and 2020. Weeding was done manually before the introduction of okra, 8 WAP and at 5 weeks after planting okra, based on the recommendation of Temnotfo and Henry, (2017). Organic compost was applied a week before planting Jatropha while NPK 20:10:10 fertilizer was applied in split at 2 and 6 WAS in the appropriate plots.

Data collection

Jatropha plant growth parameters that were assessed at full establishment on the field before the introduction of okra at 8 weeks after sowing, (WAS) and at bimonthly intervals include: i) plant height measured in cm as the distance from the soil surface to the tip of the topmost leaf, ii) numbers of fully expanded leaves counted visually, iii) canopy width (cm) as the foliage spread measured by measuring tape and iv) determination of dry matter accumulation where two plants were uprooted at the onset of flowering at 24 WAS in each sub-plot; they were washed under running tap water, separated into shoot and root, air-dried before oven-dried to constant weight at 75^0C for about 10 hours. Their respective weights were taken using measuring balance and recorded.

Statistical analysis

The data collected were subjected to Analysis of Variance (ANOVA) and significantly different treatment means were separated using Duncan's Multiple Range Test (DMRT) at P≤0.05 using the SAS (1999) statistical package.

RESULTS AND DISCUSSION

Effect of fertilizer source and cropping system on number of leaves per plant

Fertilizer application had significant positive effects on Jatropha growth at Ikenne when compared with unfertilized plants (Table 2). At 8 WAS, at Ikenne, plants grown with organic fertilizer significantly had the highest number of 18 leaves/plant which was comparable with organic + NPK of 13 leaves/ plant but were significantly higher than NPK and control treatments which had 10 leaves/ plant each. Similarly, at 16 WAS control plants had lowest of 25 leaves/plant with highest of 67 leaves/plant in the organic source until defoliation set in from 24 to 32

WAS, with an average of 40 % loss in leaf production. The non determinate growth habit of jatropha led to the observed defoliation of jatropha at 24 WAS which coincided with the onset of flowering which can vary from as early as 37 days (Annarao *et al.*, 2008) to 90 days after planting (Heller, 1996). At 32 WAS, 25 leaves/plant at 16 WAS was reduced to 10 at 32 WAS in the control plant, and from 67 to 38 leaves/plant in organic fertilizer within the same period. , Leaf production got to the peak at 48 WAS, but reduced from 87 leaves/plant, at 48 WAS, to 8 leaves/plant in the control plant at 64 WAS, which was significantly lower than the highest from organic fertilizer that reduced from 209 to 55 leaves/plant This result agrees with the reports of Owolabi *et al.,* (2016), where fertilizer had significant effect on the growth parameters of *Jatropha curcas,*. At Ibadan, leaf loss was experienced at the onset of flowering at 24 WAS as in Ikenne but results from the fertilized plants was similar with the unfertilized plants. At 64 WAS, 34 leaves/plant of the control plants was comparable with highest of 59 leaves/plant from organic + NPK which was contrary to the situation at Ikenne where fertilized plants had better growth than control plants, probably because of soil acidity with pH < 5 which undermine condition necessary for optimum availability of minerals for growing crops as reported by Robert, (2013); Ayoola and Makinde, (2014). Jatropha cultivated with organic fertilizer had significantly better growth than all the other fertilizer sources that were comparable with one another (Table 2). Higher growth shown by organic fertilizer application may be due to its ability to improve soil structure by providing organic colloids for nutrient and water retention (Ayoola and Makinde, 2014) as well as lower C/N ratio (26:1) of the compost which aids mineralization. Jatropha growth at Ikenne was at least 50 % better than that in Ibadan. The observed reduction in the number of leaves/plant of Jatropha in the two locations at 24, 32 WAS as well as 56 and 64 WAS coincided with off season periods with low soil moisture content which led to leaf senescence to reduce water loss through transpiration. According to Aderibigbe *et al.*, (1997), Jatropha can survive in poor stony soils with poor moisture condition as a result of its leaf-shedding activity, in that decomposition of the shed leaves would provide nutrients for the plant and reduce water loss during dry season (Maes *et al.*, 2009).

Jatropha had similar growth attributes, in terms of leaf production, as a sole crop and in intercrop with okra, indicating the compatibility of both crops at both sites. (Table 2). Sole crop Jatropha produced plants with similar number of leaves relative to intercropping. At 8 weeks after sowing (WAS), at Ikenne, sole crop had 13 leaves that were similar with 12 leaves from the intercrop. This value got to the peak at 16 WAS with 45 leaves from the sole crop and 41 leaves from the intercrop (Figure 2). This trend continued till 64 WAS when sole crop had 31 leaves/plant and 26 leaves/plant from the intercrop, except at 48 WAS when sole crop had 147 leaves/plant that was significantly higher than the 122 leaves/plant from intercrop. At Ibadan at 8 WAS, sole crop had 5 leaves/plant when the intercrop had comparable 4 leaves/plant. This rose to 12 and 9 leaves/plant, respectively from the sole and intercrop at 16 WAS until there was total defoliation at 24 WAS. At 32 WAS, sole crop had 11 leaves/plant which was similar to 8 leaves/plant from the intercrop. The values continued to rise from 26 and 20 leaves/plant from sole crop and intercrop, respectively at 40 WAS to 47 and 33 leaves/plant respectively, at 56 WAS. However, at 64 WAS, sole crop had 54 leaves/plant which were higher with 37 leaves/plant from the intercrop. This report is similar to the report of Geply *et al.,* (2011) who observed that intercropping of Jatropha with arable crops does not negatively affect Jatropha vegetative growth. However, at both sites, there was no significant interaction between the cropping system and type of fertilizer applied probably because of climate, soil properties and water availability.

Table 2: Effect of fertilizer source and cropping system on the mean number of leaves/plant of *Jatropha curcas*

Treatments	Weeks after sowing							
	8	16	24	32	40	48	56	64
Ikenne site								
Fertilizer (F)								
Control	10.25b	25.46b	12.21c	10.33b	70.81c	86.51c	42.80b	8.35c
NPK	10.46b	34.00b	18.88bc	20.10ab	99.10b	108.21bc	47.95b	13.33c
Organic	18.00a	67.21a	39.75a	37.75a	142.71a	208.50a	100.42a	55.80a
Organic + NPK (50:50)	12.54ab	45.29b	29.33ab	33.71a	115.36b	134.42b	102.80a	35.82b
Cropping systems (C)								
Sole	13.46	44.69	23.90	24.49	105.76	147.32a	76.04	30.65
Intercrop	12.17	41.29	26.19	26.46	108.23	121.50b	70.94	26.00
	ns	ns	ns	ns	ns		ns	ns
F*C	ns	ns	ns	ns	ns	ns	ns	ns
Ibadan site								
Fertilizer (F)								
Control	6.17	7.75	0.00	7.92	20.58	28.92	32.67	34.33
NPK	4.71	11.50	0.00	9.93	25.58	30.00	33.33	37.50
Organic	6.46	10.54	0.00	8.28	23.75	27.42	43.00	50.67
Organic+NPK (50:50)	5.67	12.33	0.00	10.34	22.78	30.00	51.17	59.17
	ns	ns	ns	ns	ns	ns	ns	ns
Cropping systems (C)								
Sole	6.08	11.73	0.00	10.56	26.17	35.17	47.25	53.50a
Intercrop	5.42	9.33	0.00	7.67	20.18	23.00	32.83	37.33b
	ns	ns	ns	ns	ns	ns	ns	
F*C	ns	ns	ns	ns	ns	ns	ns	ns

Means with same letter (s) in a column are not significantly different at 5% level of probability according to Duncan multiple range test. ns = not significant

Effect of fertilizer source and cropping system on the plant height (cm) of Jatropha curcas

At Ikenne, fertilizer application significantly ($p < 0.05$) improved Jatropha growth when compared with unfertilized plants (Table 3). With the exemption of 8 WAS, when fertilized and control tratments had similar plant height, fertilizer application produced significantly taller plants than the unfertilized plant. At 16 WAS, shortest plant of 44.5 cm was from control plant while the tallest plant (83.1 cm) was recorded from organic fertilizer treatment. Similar trend was observed till 64 WAS where organic based fertilizer treatments consistently had highest values (181.2 cm and 176.2 cm in the organic and its combination with NPK, respectively than the control with 127.13 cm which was comparable with NPK of 132.68 cm. This result agrees with the reports of Ouwens *et.al.*, (2007), where fertilizer treatment had significant effect on the growth parameters of Jatropha *curcas.* Conversely, at Ibadan, even though plant height increased from 13.98 cm in the control plants, at 8 WAP to 58.5 cm at 64 WAS, it was not significantly different from the highest value from organic+NPK treatment which increased from 12.04 cm at 8 WAS to 84.0 cm at 64 W AS. The observed similarity in growth of fertilized and control plants may be due to the acidic nature of the soil with pH < 5 which reduces efficiency of nutrient absorption by plants, thus undermining conditions necessary for optimum availability of minerals for growing crops (Robert 2013; Ayoola and Makinde, 2014). Jatropha cultivated with organic fertilizer had significantly better growth than all the other fertilizer sources which were comparable with one another (Table 3). Better growth shown by organic fertilizer application may be due to its ability to improve soil structure for nutrient and water retention (Ayoola & Makinde, 2014) and the lower C/N ratio (26:1) of the compost which aids mineralization. Jatropha growth at Ikenne was at least 50 % better than that at Ibadan.

Apart from Ibadan at 32 and 48 WAS, jatropha had similar plant height as a sole crop and in intercrop with okra, indicating the compatibility of both crops at both sites. (Table 3). At Ikenne, the increase in plant height of sole crop from 23.77 cm at 8WAS to 148.13 cm at 64 WAS was not significantly different ($p>0.05$) from intercrop with 24.14 cm at 8 WAS to 160.48 cm at 64 WAS. Similarly, in Ibadan, the increase in plant height in sole crop from 12.86 cm at 8 WAS to 79 cm at 64 WAS and in the intercrop from 13.31 cm at 8 WAS to 7.08 cm at 64 WAS was not significantly different except at 48 WAS where sole crop had significantly taller plant of 64.18 cm than 48.13 cm in the intercrop. This result agrees with the observations of Da Silva *et al.*, (2016), who reported that intercropping Jatropha with forage and grain crops does not affect biometric traits of jatropha as plant height, crown diameter, stem diameter and number of branches. Similarly, Geply *et al.,* (2011) observed that intercropping of Jatropha with arable crops, maize and vegetables, does not negatively affect Jatropha height. However, at both sites, there was no significant ($p>0.05$) interaction between the cropping system and type of fertilizer applied probably because of climate, soil properties and water availability.

Table 3: Effect of fertilizer source and cropping system on the plant height (cm) of *Jatropha curcas*

Treatments	Weeks after sowing							
	8	16	24	32	40	48	56	64
Ikenne site								
Fertilizer (F)								
Control	21.76a	44.50c	61.42b	54.64c	72.25c	113.44c	118.61b	127.13b
NPK	21.34a	57.58b	69.95b	78.90b	90.39bc	119.33bc	124.92b	132.68b
Organic	28.55a	83.10a	102.44a	108.47a	117.01a	146.69a	170.01a	181.20a
Organic+NPK (50:50)	24.18a	64.13b	81.99ab	89.25ab	99.64ab	133.28ab	166.13a	176.20a
Cropping systems (C)								
Sole	23.77	63.10	74.69	80.49	92.50	127.47	140.33	148.13
Intercrop	24.14	61.56	83.22	85.14	97.14	128.89	149.51	160.48
	ns	ns	ns	ns	ns	ns	ns	ns
F*C	ns	ns	ns	ns	ns	ns	ns	ns
Ibadan site								
Fertilizer (F)								
Control	13.98	17.99	13.71b	21.50	34.97	44.88	51.17	58.50
NPK	11.67	22.62	20.20a	27.00	41.70	54.38	64.67	71.83
Organic	14.66	23.12	19.62a	23.51	42.94	59.84	73.67	77.83
Organic+NPK (50:50)	12.04	21.60	19.67a	24.52	37.86	61.50	74.83	84.00
	ns	ns		ns	ns	ns	ns	s
Cropping systems (C)								
Sole	12.86	22.67	19.31	26.41a	40.76	64.18a	73.08	79.00
Intercrop	13.31	20.00	17.30	21.85b	37.97	46.13b	59.08	67.08
	ns	ns	ns		ns		ns	ns
F*C	ns	ns	ns	ns	ns	ns	ns	ns

Means with same letter (s) in a column are not significantly different at 5% level of probability according to Duncan multiple range test. ns = not significant

Effect of fertilizer source and cropping system on the canopy width (cm) of Jatropha curcas

At Ikenne, as a result of better access to nutrient, fertilized had significantly better canopy coverage than unfertilized plants (Table 4). At 48 WAS, organic fertilizer significantly had the highest canopy width of 139.3 cm which was significantly higher than from other sources. While canopy width of NPK (109.04 cm) and organic + NPK (139.3 cm) were comparable, they were significantly higher than control which had the lowest of 82.51 cm. Similar trend was observed till 64 WAS when the widest canopy was enhanced by organic fertilizer sources, (169.83 cm and 130.97 cm in organic and its combination with NPK, respectively) followed by NPK and the least value of 95.32 cm from control plant. However, at Ibadan, canopy width did not vary with fertilizer treatment except at 64 WAS when fertilized plants had significantly higher canopy width than the control plants with the least of 3.33 cm and highest value of 63.67 cm from organic + NPK application. Similarly, fertilized plants, with organic fertilizer producing the best result, had significantly better canopy spread (Gebrehana, 2014), which enhances photosynthetic activities, than unfertilized plants. However, at both sites, there was no significant interaction between the cropping system and type of fertilizer applied.

Growth of jatropha expressed as canopy width had similar values as a sole crop or in intercrop in both locations. (Table 4). Canopy formation as a result of branching was more visible from 48 WAS at both locations. At Ikenne, canopy width increased from 114.39 cm at 48 WAS to 131.85 at 64 WAS in the sole but this was not different significantly from the intercrop where canopy width increased from 105.51 cm to 127.91 cm within the same period. Similar trend was observed at Ibadan where canopy width in the sole crop increased from 37.48 cm at 48 WAS to 55.33 cm at 64 WAS but was not different significantly from the intercrop with 24.48 cm at 48 WAS and 41.83 cm at 64 WAS. With these results, canopy coverage at Ikenne was at least 100 % better than that of Ibadan site. Similar result was reported by Da Silva *et al.*, (2016), where canopy width value of jatropha under monocropping was at par with those intercropped with forage and grain crops as a result of its ability to compete substantially with arable crops for nutrients (Openshaw, 2000).

Effect of fertilizer source and cropping system on the dry matter yield of Jatropha

While fertilized plants (192-205 g/plant at Ikenne and 135-160 g/plant at Ibadan) produced significantly more assimilates than the unfertilized plants of 161.06 g/plant at Ikenne and 94.6 g/plant at Ibadan (Table 5) as a result of nutrient availability in the fertilized plants which make more assimilates available for plant growth and yield production (Akanbi *et al.*, 2010). Highest yield was from organic + NPK even though it was similar with other sources. Dry matter yield was generally higher at Ikenne located in the rainforest zone than in the transitional zone of Ibadan site.

Dry matter yield of Jatropha as a sole crop and under intercrop in the two ecological locations were similar, indicating no yield interference due to its intercrop with okra (Table 5). There was more dry matter accumulation in the root, between 5 to 35 %, than in the shoot. This position was affirmed by Santos *et al.*, (2017) who observed that during the early growth of Jatropha plants, the leaves act as a strong sink and as the plant grows, they become highly mobile sources of nutrients (N, P and K) which may have been responsible for reduction in shoot assimilate over time to boost rooting for proper plant establishment. Consequently, stem growth will begin to promote the redistribution of photo assimilates, leading to a reduction in dry mass in the leaves (Santos *et al.*, 2013).

Table 4: Effect of fertilizer source and cropping system on the canopy width (cm) of *Jatropha curcas*

Treatment	Weeks after sowing		
	48	56	64
Ikenne site			
Fertilizer(F)			
Control	82.51c	90.65c	95.32c
NPK	109.04b	117.85b	123.41b
Organic	139.30a	163.46a	169.83a
Organic+NPK (50:50)	108.96b	126.34b	130.97b
Cropping systems(C)			
Sole	114.39	126.15	131.85
Intercrop	105.51	122.99	127.91
	ns	ns	Ns
F*C	ns	ns	ns
Ibadan site			
Fertilizer(F)			
Control	20.96	27.17	31.33b
NPK	28.71	35.50	40.17a
Organic	38.92	52.67	59.17a
Organic+NPK (50:50)	35.33	55.00	63.67a
	ns	ns	
Cropping systems(C)			
Sole	37.48	49.33	55.33
Intercrop	24.48	35.83	41.83
	ns	ns	Ns
F*C	ns	ns	ns

Means with same letter (s) in a column are not significantly different at 5% level of probability according to Duncan multiple range test. ns = not significant

Table 5: Effect of fertilizer source and cropping system on the dry matter yield (g/plant) of Jatropha

Treatments	Shoot weight	Root weight	Plant dry weight.
Ikenne			
Fertilizer (F)			
Control	70.61b	90.45b	161.06b
NPK	95.5a	97.1b	192.6a
Organic	85.3a	111.7a	197.0a
Organic+NPK (50:50)	83.1a	122.5a	205.6a
Cropping systems (C)			
Sole	38.88	45.3	84.18
Intercrop	35.62	50.2	85.82
	ns	ns	ns
F*C	ns	ns	ns
Ibadan			
Fertilizer (F)			
Control	44.4b	50.5b	94.9c
NPK	62.1a	82.2a	144.3b
Organic	60.4a	75.1a	135.5b
Organic+NPK (50:50)	74.7a	85.5a	160.2a
Cropping systems (C)			
Sole	22.6	30.6	53.2
Intercrop	24.1	31.3	55.4
	ns	ns	ns
F*C	ns	ns	ns

Means with same letter (s) in a column are not significantly different at 5% level of probability according to Duncan multiple range test. ns = not significant

CONCLUSIONS

Growth of jatropha, measured by number of leaves per plant and height and canopy width, was not affected by intercropping with okra because its performance is comparable to sole jatropha, giving evidence of their compatibility. Higher dry matter partitioning, enhanced by fertilizer application, to the rooting system than the shooting system in sole and intercropped jatropha confirmed its ability to ensure proper plant establishment and growth especially in erosion-prone areas. Hence, jatropha will thrive either as a sole crop or when intercropped with okra under organic fertilizer application which will improve its dry matter yield and subsequently seed yield.

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