WFL Publisher
Science and Technology

Meri-Rastilantie 3 C, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.4 (3&4) : 192-196. 2006 www.world-food.net

Effect of sowing depth on emergence, growth and yield of okra (*Abelmoschus esculentus* (L.) Moench)

F. O. Odeleye [1*], O.M.O. Odeleye [2], A. O. Olaleye [3] and F.B. Yakubu [4]

*[1] Department of Crop Protection & Environmental Biology. University of Ibadan, Nigeria. [2] National Horticultural Research Institute, Jericho, Idi–Ishin, Ibadan. [3] Dept. of Soil Science & Farm Mechanization, Olabisi Onabanjo University, P.M.B.2002, Ago–Iwoye, Ogun State, Nigeria.[4] Federal School of Forestry, Jericho, Ibadan, Nigeria. *e-mail: gbengaodeleye2@yahoo.com*

Received 11 December 2005, accepted 22 July 2006.

Abstract

Pot and field trials were conducted to evaluate the effects of sowing depth on the performance of two varieties of okra grown as a sole crop. The pot experiment involved a factorial combination of 5 sowing depths (1, 2, 3, 4 and 5 cm) with 2 varieties of okra. The pots were arranged in randomized complete block design with four replications. The pot experiment was conducted on the roof top garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria. The field experiment was a repetition of the pot experiment and was done at the Teaching and Research Farm, University of Ibadan. Data were taken on number of days from planting to emergence and on growth and yield parameters. Data from the experiments were subjected to ANOVA using SAS and means were separated using LSD and S.E. Results showed that sowing okra at 4 and 5 cm depth significantly reduced seedling emergence (%) and caused a significant decrease in the vegetative growth, dry matter accumulation and yield of okra varieties in pots and on the field. The 5 cm depth appears to be the most damaging in this regard. Good seedling emergence was obtained at 1, 2 and 3 cm sowing depth but the 3 cm depth appears to be the optimum sowing depth for okra, as the highest yield and the overall best performance of okra were attained at this depth. The two varieties of okra used in this study responded similarly to depths of sowing but NHA_e47-4 (early maturing) out yielded LD88 (medium maturing) apparently because of its longer life cycle and larger leaf area, which enabled it to produce more fruits over time during its life cycle.

Key words: Sowing depth, okra, emergence, growth, yield.

Introduction

Okra (*Abelmoschus esculentus*) is an annual vegetable crop cultivated throughout Nigeria [2, 7]. Farmers usually cultivate okra intercropped with major food crops like yam, maize and cassava [4]. Occasionally it is grown as a sole crop. While planting okra seeds, farmers usually open up the soil and throw in a couple of seeds and cover up the soil without using a specific depth. The potential of the resulting seedlings may not be fully realized since a shallow depth of sowing may lead to lodging of the plant during a light rainstorm later in its life cycle and an excessively deep planting may result in non-emergence of the seedling. Depth of planting has been shown to have a varied effect on the performance of crops [1, 5, 6, 8]. Depending on soil type, depth of sowing may determine days to emergence, plant vigour and eventual yield of crops. Tayo [8] reported that deeply planted pigeon pea delayed emergence, adversely affected plant vigour and led to reduced yield. Similarly Alessi and Power [3] reported that one additional day was required for corn emergence for each 2.5 cm increase in depth of planting. Fehr *et al.* [5] found that planting depth had a major influence on emergence percentage of corn. Average emergence was 73% from 5 cm and 44% from 10 cm. Emergence as low as 13% was observed with the 10 m depth. Abrecht [1] reported that deep planting slowed emergence but increased seedling growth in maize and particularly in soybean. Given the need to optimize sowing depth in okra and the desirability to have lodging resistant plants vis-à-vis optimum planting depth which will also place the root at a vantage position to tap soil nutrients and absorb water, it is imperative to investigate the optimum sowing depth for okra cultivation. The objective of this study, therefore, was to determine the optimum sowing depth for okra cultivation.

Materials and Methods

Pot experiment: A pot trial was carried out on the open roof top garden of the Department of Crop Protection and Environmental Biology, University of Ibadan. Forty plastic pots (20 cm rim diameter) were each filled with 5.0 kg soil. The seeds of okra varieties, medium maturing LD88 (V_1) and early maturing NHA_e47-4 (V_2), were obtained from the National Horticultural Research Institute (NIHORT), Ibadan. The seeds of these okra varieties were sown in forty plastic pots on 12 August 2003 at varying depths (1, 2, 3, 4 and 5 cm). Thinning was done 2 weeks after sowing. Fertilizer was applied at the rate of 80 kg NPK (15:15:15) so that 1.5 g of NPK fertilizer was incorporated into the soil in each pot. Plants were sprayed 5 weeks after sowing with 50 g a.i ha^{-1} of Sharper plus to control insects. The experiment was a factorial combination of varieties and 5 sowing depths in RCBD with four replications. Data were taken on seedling emergence % and vegetative characteristics, dry matter accumulation and yield characteristics. Data analysis was done using ANOVA and means were compared using LSD at (5%) level and standard error.

Field experiment: The field trial was carried out at the Teaching and Research Farm, University of Ibadan during the late season of 2003 (Sept. – Dec. 2003). The size of plot used was 12 m x 8 m. This was divided into four blocks (replications) each measuring 8.5 m x 3 m. Each block was subdivided into 10 micro-plots each 1.5 m x 3 m. The experiment was a 2 x 5 factorial trial in randomized complete block design.

The seeds of okra varieties, medium maturing LD88 (V_1) and early maturing NHA_e47-4 (V_2), obtained from the National Horticultural Research Institute (NIHORT) Ibadan, were planted on the field at depths of 1, 2, 3, 4 and 5 cm (D_1, D_2, D_3 D_4 and D_5, respectively) as done in the pot experiment. The spacing was 30 cm x 60 cm. The 10 treatments were randomized completely within each block separately using the random digit of numbers. The experiment was a 2 x 5 factorial trial in randomized complete block design with 4 replications. The soil was a non-crusting one with properties shown in Table 1.

Weeding was done at 3 and 6 weeks after sowing. Fertilizer (N:P:K, 15:15:15) at the rate of 80 kg was applied by side dress three weeks after planting, after the 1st weeding. Thinning was done 2 weeks after sowing. Insects were controlled using Sharper plus 280 at 12.5 ml per litre of water.

Successive harvesting was done thrice as fruits reached marketable size. Number of fruits was counted on each occasion and fresh weight obtained to determine yield. The vegetative parameters assessed included plant height, number of branches, number of leaves and leaf area. At final harvest, the okra plants were partitioned into leaves, stem, root and pods and oven-dried in brown envelopes for 48 hours at 80°C. Dry weight measurements were taken of stem, leaves, root and fruits and the total dry weight was calculated by addition.

The data collected were subjected to analysis of variance and the mean differences were compared using LSD at 5% level of significance and standard error.

Results

Pot experiment

Effect of sowing depth on seedling emergence: Seedling emergence percentage was highest in seeds sown at 1 cm depth while seeds sown at 5 cm depth had the lowest seedling emergence percentage. Seedling emergence at depths 2, 3 and 4 cm was not significantly different at 5% level of significance (Table 2).

Effect of sowing depth on vegetative characteristics and yield: Seeds sown at the depth of 3 cm produced plants with the highest number of leaves, fruits and fruit fresh weight (Table 3). Stem height and number of branches were not significantly different at all depths in the pot experiment. The varieties did not show any significant difference in respect of most of the vegetative characters considered. D_1 D_2 and D_3 had similar fruit number and fruit fresh weight while D_5 had the lowest values of all vegetative and yield parameters considered (Table 3).

On interactions, LD88 and NHA_e47-4 produced the highest number of fruits and fruit fresh weight at depth of 3 cm even though NHA_e47-4 had slightly higher values of these parameters. There was no vivid difference on the interaction of vegetative characters considered (Table 3).

Effect of sowing depth on dry matter accumulation: Plants from seeds sown 1, 2 and 3 cm deep accumulated similar amount of dry matter in the various plant parts but higher than those of D_4 and D_5 plants which had relatively lower dry matter in the various plant parts (Table 4). Differences in dry matter were most vivid in fruit dry weight and total dry weight. D_3 plants had the highest dry weight of fruit and total dry weight. D_5 plants accumulated the lowest amount of dry matter in all the plant parts and overall. NHA_e47-4 accumulated slightly higher dry matter than LD88 in the various plant parts but the differences were not significant. The two varieties accumulated the highest dry matter at the depth of 3 cm (Table 4).

Table 1. Physical and chemical characteristics of the soil used for the experiments.

Particle size distribution (%)		
Sand	85.2	
Silt	6.8	
Clay	8.0	
Chemical composition		
Acidity (me/100 g)		0.72
Exchangeable cations (me/100g)		0.20
Total N (%)		0.09
Organic C (%)		1.06
Available P (ppm)		1.41
K (me/100 g)		0.36
Ca (me/100 g)		1.70
Na (me/100 g)		0.33
Mg (me/100 g)		0.72
Mn (ppm)		20.30
Fe (ppm)		10.40
Cu (ppm)		1.50
Zn (ppm)		4.10
pH in H_2O		5.1

Table 2. Effect of sowing depth on seedling emergence percentage of two varieties of okra grown in pots.

Sowing depth	4 DAS	5 DAS	7 DAS
D_1	78.40	88.60	89.20
D_2	69.80	79.30	84.50
D_3	66.60	75.80	80.81
D_4	40.20	48.70	53.60
D_5	36.50	42.60	50.70
LSD(P=0.05)	11.62	12.58	12.65
Variety			
V_1	60.78	68.76	72.42
V_2	55.82	65.44	71.30
LSD(P=0.05)	11.62	12.58	12.65
Interactions			
V_1			
D_1	82.60	90.40	89.40
D_2	71.20	78.60	84.80
D_3	68.50	78.80	80.10
D_4	43.10	49.50	81.60
D_5	38.50	46.50	54.60
V_2			
D_1	74.20	87.80	51.70
D_2	68.40	80.00	89.00
D_3	64.70	72.80	84.20
D_4	37.30	47.90	52.60
D_5	34.50	38.70	49.70
S. E	5.36	6.14	6.23

D_1, D_2, D_3, D_4 and D_5 = 1, 2, 3, 4 and 5 cm sowing depths, respectively; V_1= LD88 (medium maturing variety), V_2=NHA_e47-4 (early maturing variety); S.E. = Standard error; DAS = days after sowing.

Table 3. Effect of sowing depth on vegetative characters and pod yield of two okra varieties grown in pots.

Sowing depth	Number of leaves plant^{-1}	Leaf area cm^2 plant^{-1}	Stem height cm plant^{-1}	Number of branches plant^{-1}	Number of fruits plant^{-1}	Fruit fresh weight g plant^{-1}
D_1	8.25	141.65	32.18	2.3	3.25	17.57
D_2	8.50	147.70	29.59	2.4	3.50	18.22
D_3	9.25	155.8	28.78	2.1	4.13	19.58
D_4	8.75	13908	27.91	2.1	2.38	15.02
D_5	6.90	129.1	24.25	1.5	2.00	14.17
LSD (P = 0.05)	2.57	6.5	9.80	1.56	0.95	2.04
Variety						
V_1	8.55	136.4	29.3	2.10	2.85	16.54
V_2	8.10	149.2	27.79	2.00	3.25	17.26
LSD (P = 0.05)	2.57	6.5	9.80	1.56	0.95	2.04
Interactions						
V_1						
D_1	8.50	136.8	35.25	2.0	3.0	17.53
D_2	8.25	142.8	30.05	2.8	3.25	17.96
D_3	10.0	150.3	28.03	2.0	3.75	19.22
D_4	8.75	129.7	26.95	2.3	2.25	14.37
D_5	7.25	122.4	26.20	1.5	2.0	13.58
V_2						
D_1	8.00	146.5	29.10	2.5	3.5	17.60
D_2	8.75	152.6	29.10	2.0	3.75	18.49
D_3	8.50	161.3	29.50	2.3	4.5	19.94
D_4	8.75	149.9	28.90	2.0	2.5	15.66
D_5	6.50	135.7	22.30	1.5	2.0	14.60
S.E.	1.25	3.1	4.85	0.76	0.46	0.995

D_1, D_2, D_3, D_4 and D_5 = 1, 2, 3, 4 and 5 cm sowing depths, respectively; V_1= LD88 (medium maturing variety), V_2= NHA$_e$47-4 (early maturing variety); S.E. = Standard error.

Table 4. Effect of sowing depth on dry matter accumulation of okra varieties grown in pots.

Sowing depth	Leaf dry wt. g plant^{-1}	Stem dry wt. g plant^{-1}	Root dry wt. g plant^{-1}	Fruit dry wt. g plant^{-1}	Total dry wt. g plant^{-1}
D_1	2.25	4.60	1.43	5.06	13.33
D_2	2.94	4.23	1.46	5.69	14.32
D_3	3.12	4.18	1.26	6.66	15.22
D_4	2.75	3.93	1.12	4.29	12.09
D_5	2.45	3.76	1.34	3.89	11.45
LSD (P = 0.05)	0.68	1.51	3.38	0.87	2.30
Variety					
V_1	2.55	4.42	1.44	4.54	12.96
V_2	2.86	3.86	1.18	5.69	13.59
LSD (P = 0.05)	2.57	9.80	3.38	0.87	2.30
Interactions					
V1					
D1	2.15	5.27	1.49	4.58	13.49
D2	2.53	4.33	1.53	4.81	13.20
D3	2.91	34.28	1.49	5.98	13.65
D4	2.85	4.21	1.19	3.83	12.08
D5	2.31	5.01	1.57	3.53	12.42
V2					
D1	2.35	3.92	1.36	5.54	13.16
D2	3.35	4.13	1.38	6.57	15.43
D3	3.34	5.08	1.04	3.34	16.79
D4	2.65	3.66	1.04	4.75	12.09
D5	2.59	2.52	1.10	4.25	10.47
S.E.	0.33	0.73	1.16	0.42	1.10

D_1, D_2, D_3, D4 and D_5 = 1, 2, 3, 4 and 5 cm sowing depths, respectively; V_1= LD88 (medium maturing variety), V_2=NHA$_e$47-4 (early maturing variety); S.E. = Standard error.

Field experiment

Effect of sowing depth on percentage seedling emergence: The highest percentages of seedling emergence were recorded at sowing depths of 1 and 2 cm, while the lowest one was recorded at the depth of 5 cm (Table 5). Even at seven days after sowing, seeds sown at 5 cm depth had only 52.53% emergence which was significantly lower than emergence at 1 and 2 cm. Overall best seedling emergence was recorded at the depth of 1 cm. The seedlings of V2 appeared to emerge much earlier than seedlings of V1 with V2 having higher seedling emergence 4DAS. Thereafter, the % seedling emergences of the two varieties were similar (Table 5).

From the interactions, the highest emergence of LD88 (V_1) was obtained when sown at the depth of 1cm (V_1D_1 = 85.00 and 86.68 at 4 and 6 DAS, respectively) and in NHA$_e$47-4 the emergence was also best at the depth of 1cm V_2D_1= 75.55 and 81.90 at 5 and 7 DAS, respectively. The lowest emergence by both varieties was obtained at the depth of 5 cm (Table 5).

Effect of sowing depth on vegetative characters: The number of leaves of plants produced at various sowing depths was not significantly different from one another, except D_5 plants produced significantly lower number of leaves than D_4 plants. The two okra varieties produced the highest number of leaves when sown at the depth of 4 cm (Table 6).

Plants sown at 3 cm depth (D_3) had the largest leaf area while plants with seeds sown 5 cm deep had the lowest leaf area plant^{-1}. The leaf area of D_3 was significantly higher than that of D_1 but similar to that of D_2. V_2 (NHA$_e$47-4) had a significantly higher leaf area than V_1. The two varieties produced the largest leaf area at the depth of 3 cm (Table 6).

The tallest okra plants were those from seeds sown at the depth of 1 cm (D_1) with height of 55.83 cm followed by plants with seeds sown at 3 cm. Plants resulting from seeds sown at the depth of 5 cm (D_5) were the shortest with mean height of 35.11 cm (Table 6).

The maximum number of branches was produced at the depth of 3 cm while plants from seeds sown at the depth of 5 cm produced the least number of branches. However, all the treatments showed no significant difference from one another in respect of number of branches (Table 6).

Seeds sown at 5 cm depth produced plants with the longest roots (19.11 cm), while D_1 plants had the shortest roots (10.56 cm). The root of D_5 plants was significantly longer than that of D_3 plants which was in turn significantly longer than that of D_1 plants (Table 6).

Table 5. Effect of sowing depth on percentage seedling emergence of two varieties of okra on the field.

Sowing depth	4 DAS	5 DAS	7 DAS
D_1	75.95	82.28	84.29
D_2	63.68	78.73	82.41
D_3	66.91	76.68	80.46
D_4	37.91	52.50	55.00
D_5	35.38	49.69	52.53
LSD (P=0.05)	10.18	13.45	12.63
Variety			
V_1	51.8	68.51	71.34
V_2	60.16	67.44	70.54
LSD (P=0.05)	10.18	13.45	12.63
Interactions			
V_1			
D1	80.0	85.00	86.68
D2	56.83	79.98	84.00
D3	59.68	76.68	80.10
D4	32.5	51.65	55.00
D5	30.0	49.25	50.90
V_2			
D1	71.90	79.55	81.90
D2	70.53	77.48	80.83
D3	74.15	76.68	80.83
D4	43.33	53.35	55.00
D5	40.88	50.13	54.20
S. E	5.02	6.55	5.98

D_1, D_2, D_3, D_4 and D_5 = 1, 2, 3,4 and 5 cm sowing depths, respectively; V_1= LD88 (medium maturing variety), V_2=NHA$_e$47-4 (early maturing variety); S.E. = Standard error; DAS= days after sowing.

Effect of sowing depth on dry matter accumulation: D_4 plants had the highest dry weight of leaves, stems and roots while D_3 plants had the highest fruit dry weight and the highest total plant dry weight. D_5 plants accumulated the lowest dry matter in the various plant parts and overall. In line with the more vigorous nature of V_2 (NHA$_e$47-4), it accumulated the highest dry matter in the various plant parts and overall compared to V_1 (LD88) (Table 7).

Effect of sowing depth on marketable yield: Seeds sown at 3 cm depth (D_3) produced plants with the highest number of fruits. The lowest number of fruits was produced by D_4 and D_5 plants. The variety NHA$_e$47-4 produced more fruits compared with LD88. The interaction showed that V_1D_3 and V_2D_3 produced the highest number of fruits.

The highest marketable yield (fresh fruit wt.) was produced by plants the seeds of which were sown at 3 cm depth (D_3) and was not significantly different from fruit fresh weight of D_1 and D_2 plants. D_4 and D_5 plants produced the lowest fruit fresh weight (Table 6). V_2 had higher fruit fresh weight than V_1. V_1D_3 and V_2D_3 produced the highest fruit fresh weight among the treatments.

Discussion

The results showed that sowing depth has a profound effect on the overall performance of okra. Very deep planting (5 cm) delayed emergence and adversely affected growth and yield of okra. The delayed/poor emergence of seeds planted at the 5 cm depth may be due to the inability of amount of food reserve in okra seed to support the growth of the hypocotyls above the soil. This must have resulted in the death of these seedlings before reaching the soil surface.

Table 6. Effect of sowing depth on vegetative characters and yield of okra grown on the field.

Sowing depth	No of leaves plant^{-1}	Leaf area cm^2 plant^{-1}	Stem height cm plant^{-1}	No of branches plant^{-1}	Root length cm plant^{-1}	Number of fruits plant^{-1}	Fruit fresh weight plant^{-1}
D_1	9.38	179.80	55.83	1.88	10.56	1.00	47.10
D_2	9.25	184.34	51.83	1.38	13.13	1.38	33.50
D_3	9.88	187.63	53.00	2.25	14.88	1.88	34.00
D_4	11.88	176.73	47.56	1.88	12.29	0.88	16.99
D_5	8.13	153.28	35.11	0.75	19.11	0.88	10.02
LSD (P = 0.05)	3.57	7.9	12.89	1.42	3.98	1.13	8.91
Variety							
V_1	9.85	172.25	51.45	1.75	11.47	1.10	11.05
V_2	9.55	180.50	45.88	1.50	12.51	1.30	18.37
LSD (P = 0.05)	3.57	7.9	12.89	1.42	3.98	1.13	8.91
Interactions							
V_1							
D_1	12.00	177.5	62.25	2.75	9.13	2.00	15.25
D_2	7.50	181.7	56.25	1.50	13.75	2.25	19.32
D_3	11.75	184.1	58.50	2.50	15.25	3.25	11.40
D_4	11.78	167.3	48.50	1.50	11.63	1.50	9.51
D_5	7.00	150.6	31.73	0.50	7.60	2.00	9.40
V_2							
D_1	6.67	182.1	49.40	1.00	12.00	2.25	14.20
D_2	11.00	186.9	47.38	1.25	12.50	2.25	12.11
D_3	8.00	191.2	47.50	2.00	14.50	2.50	10.01
D_4	12.75	186.2	46.63	2.25	12.95	2.50	8.75
D_5	9.25	155.9	38.50	1.00	10.63	2.25	7.15
S.E.	1.74	3.85	6.29	0.69	1.94	0.52	1.23

D_1, D_2, D_3, D_4 and D_5 = 1, 2, 3,4 and 5 cm sowing depths, respectively; V_1= LD88 (early maturing variety), V_2=NHA$_e$47-4 (medium maturing variety); S.E. = Standard error.

Table 7. Effect of sowing depth on dry matter accumulation of okra grown on the field.

Sowing depth	Leaf dry wt. g plant^{-1}	Stem dry wt. g plant^{-1}	Root dry wt. g plant^{-1}	Fruit dry wt. g plant^{-1}	Total dry wt. g plant^{-1}
D_1	5.21	7.85	2.27	9.64	25.17
D_2	4.70	6.96	2.37	7.57	21.60
D_3	5.06	8.18	2.80	13.05	29.09
D_4	7.19	8.56	3.30	6.62	25.67
D_5	4.34	3.69	1.81	5.96	15.80
LSD (P = 0.05)	1.87	2.87	2.48	7.20	8.1
Variety					
V_1	5.13	7.27	2.66	6.22	21.28
V_2	5.47	6.83	2.36	10.99	25.65
LSD (P = 0.05)	1.87	2.87	2.48	7.20	8.1
Interactions					
V_1	5.50	8.5	11.10	21.73	46.83
D_1					
D_2	3.65	6.86	10.32	27.52	48.35
D_3	6.48	9.67	12.12	48.84	77.11
D_4	6.18	8.20	12.57	12.88	39.83
D_5	3.86	3.10	7.17	13.50	27.63
V_2	4.92	7.2	7.04	57.00	76.16
D_1					
D_2	5.75	7.08	8.63	33.03	54.49
D_3	3.64	6.69	10.26	55.56	76.15
D_4	8.20	8.93	13.9	40.13	71.16
D_5	4.82	4.29	7.28	34.21	50.60
S.E	1.4	3.22	1.21	3.50	3.9

D_1, D_2, D_3, D_4 and D_5 = 1, 2, 3,4 and 5 cm sowing depths, respectively;V_1= LD88 (medium maturing variety), V_2=NHA$_e$47-4 (early maturing variety); S.E. = Standard error.

In addition, even though the two varieties used did not show any significant difference in emergence, indicating that their emergence percentage was similar at the various depths considered in this study, the interactions showed that in the two varieties, emergence generally decreased with increase in sowing depth. This trend has been reported by Tayo [8] in pigeon pea, and Fehr *et al.* [5] and Abrecht [1] in corn. The results of this study showed that at 4 and 5 cm depths emergence was drastically and significantly reduced. It is therefore suggested that okra should not be planted more than 3 cm deep for good emergence and establishment.

The seeds of cowpea can be sown at a depth of up to 6 cm for effective emergence and establishment. This study has therefore shown and confirmed that the size of a seed influences the depth at which it may be sown for effective emergence and establishment.

One obvious fact about vegetative characters in this study is that the lowest values of these parameters were recorded in D_5 plants and often followed by D_4 plants. This indicated that planting at 4 and 5 cm depths actually caused reduced vigour and stunted growth in okra. The variety NHA$_e$47-4 performed better in terms of fruit number and fruit fresh weight. Being an early maturing variety and having somewhat higher leaf area, it was in a position to produce more fruits during the life cycle with ultimate higher fruit fresh weight compared to LD88 which is medium maturing. The D_3 treatment produced plants with the highest fruit number as well as fruit fresh weight. It appears therefore, that 3 cm is apt for optimum emergence, growth and yield of okra under the prevailing environmental conditions in this study.

The highest dry matter accumulation at 3 cm (D_3) and lowest at 5 cm (D_5) also suggests that the roots of D_3 plants were probably placed at a position whereby they were able to tap the resources of the top soil to maximum advantage. The D_5 plants probably had their root down far away from the zone of maximum nutrient concentrations and organic matter of the soil which probably explains their low productivity. The highest level of nutrients and organic matter are known to be at the 1st few cm of the top soil in the tropics.

References

[1]Abrecht, D.G. 1989. No–till crop establishment on red earth soils at Katherine, Northern Territory: effect of sowing depth and firming wheel pressure on the establishment of cowpea, mung bean, soybean and maize. Australian Journal of Experimental Agriculture **29**:397–402.

[2]Akoroda, M.O., Anyim, P.A. and Eniola I.O.A. 1985. Edible fruit productivity and harvest duration of okra in southern Nigeria. Tropical Agriculture **63**(2):110–112.

[3]Alessi, J. and Power, J.F. 1971. Corn emergence in relation to soil temperature and seeding depth. Agronomy Journal **63**:717– 718.

[4]Ayodele, J.A. 1993. Yield responses of okra *Abelmoschus esculentus* (L.) Moench to NPK fertilizer. National Horticultural Research Institute Research Bull. **13**:1–6.

[5]Fehr, W.R., Burris, J.S. and Gilman, D.F. 1973. Soybean emergence under field conditions. Agronomy Journal **65**:740–742.

[6]Gupta, S.C., Schneider, E.C. and Swan, J.B. 1989. Planting depth and tillage interactions on corn emergence. Soil Sci. Soc. Am. J. **52**:1122–1127.

[7]National Horticultural Research Institute (NIHORT) 2002. Twenty five years of research into horticultural crops development in Nigeria 1975 – 2000. NIHORT Press Ltd., Ibadan, pp. 33–59.

[8]Tayo, T.O. 1983. Growth, development and yield of pigeon pea in the lowland tropics: 5. Effect of sowing depth. J. Agric Sci. Camb. **101**:435–440.