Effect of Heap Size and Fertilizer Application Yam *(Dioscorea Rotundata)* in Southern Nigeria

B.T. Kang and J.E. Wilson
Plant Breeders, International
Institute of Tropical Agriculture
Nigeria

Abstract

Field trials were conducted in the forest zone of southern Nigeria to study the effects of planting on flat versus various heap sizes and NPK fertilizer application on performance of local yam (*Dioscorea rotundata*), cultivar Laoko.

Heap size appeared to have a more pronounced effect on tuber yield than fertilizer application even on land which was in the second and third years of cropping after bush fallow clearing. The average tuber yield across three locations with no fertilizer application was 7.83 t/ha on the flat compred with 9.44 t/ha on large heap (about 30 cm height). With fertilizer application, tuber yields were 7.43 t/ha on the flat and 11.30 t/ha on large heap, respectively. Total yield reduction with planting on flat may in part be related to physical soil impedence. Planting on large heaps also resulted in longer tubers and shorter time for harvesting. On the Alagba soil site fertilizer application increased tuber number/plant.

Introduction

White yam (*Dioscorea rotundata*) is widely grown in West Africa. The area of production extends from the humid forest zone to the southern parts of the savannah. The crop is grown in dryland as well as in hydromorphic bottom land, although preference is often given to the hydromorphic soil, because of its higher productivity.

Various methods of seed bed preparation used in yam planting include planting on heaps or mounds, in holes, on ridges, or on flats (Onwueme, 1977). Planting on heaps is the most common practice in traditional agriculture (Coursey, 1967; Waitt, 1963). The size of heaps used varies, depending on soil type, and depth of water table (Torto, 1956). Onwueme (1978) listed four major advantages for planting on heaps: (a) to provide loose seed-bed for tuber penetration, (b) to collect fertile top soil from the surrounding area in the heap, (c) to facilitate harvesting and (d) for water control in areas with high water table.

To better study the effect of heap size in relation to soil type and fertilizer application on yield performance of yam, trials were conducted in the forest zone of southern Nigeria and the results are reported in this paper.

Experimental Materials and Methods

Two trials were carried out at Ibadan on soils derived from basement complex rocks, respectively on: (a) Ibadan soil series (Oxic paleustalf) which is developed on gravelly quartzitic slope, overlaying sedentary material from banded genesis. The surface and sub soils have a loamy sand texture, with varying concentrations of quartzite and laterite gravels. The experimental site was in the third year after clearing from grass fallow, and (b) Egbeda soil series (Oxic paleustalf) which is developed on collovium and residum derived from pre-Cambrian banded biotite muscovite gneiss. The surface soil is gravelly and has a sandy loam texture and a clay loam subsoil with high concentration of quartzite gravel. The experimental site was in the third year after clearing from secondary forest. The third trial was carried out at Ikenne on an Alagba soil series (Oxic paleustalf) which is developed on coastal sediments and materials derived from sandstones. The surface and subsoils have a sandy loam texture. The experimental site was in the second year after clearing from *Eupatorium* fallow. Some of the characteristics of the surface soils from the three experimental sites are shown in Tables 1 and 2.

The experiments were carried out using a split-plot design with four replications. There were two main plot treatments; (a) no fertilizer and (b) fertilizer applied at a rate of 60 N-13P-25K in kg/ha. Phosphorus (single superphosphate) and K (muriate of potash) were incorporated in the soil during land preparation. Half of the N (urea) was applied in a ring around the plant at about 4 weeks after planting and the remainder 6 weeks thereafter. The subplots were made up of four methods of seedbed preparation as follows: (1) planting on flat, (2) planting on "small" size heap prepared by heaping the surface soil from an area of 50 x 50 cm, (3) planting on "medium" size heap, prepared by heaping the surface soil from an area of 100 x 100 cm and (4) planting on "large" size heap, prepared by heaping the surface soil from an area of 150 x 150 cm (Figure 1).

Pre-sprouted tuber setts of approximately 75 grams in weight of yam variety Laoko were used as planting material. Soon after planting they were mulched with dried grass. A planting distance of 150 x 150 cm was used. Plants were staked. Harvested subplot size consist of 12 plants. The setts were planted around the middle of March and harvested at the end of October. Harvest time, tuber length, tuber number and tuber weight were determined at harvest.

To determine the nutrient status of the plant, first fully mature leaves were collected a week after the second N-dressing at the Ikenne site. Leaf samples were dried at 65°C and grinded. Nitrogen content was determined using the micro-Kjeldahl method. Part of the plant samples were wet-digested using a mixture of HNO_3-$HCLO_4$; P content of the digest was measured using Technicon auto-analyzer, K and Ca with flame photometer, while Mn and Zn contents were determined using a Perkin Elmer 403 atomic absorption spectrophotometer.

Soil analysis was performed on the surface and subsoil samples. Particle size analysis was determined by the hydrometer method; bulk density was measured by the core sampling method; soil pH was measured with a glass electrode using a 1:1 soil: water ratio; soil organic carbon by the Walkley and Black method; CEC was estimated from the sum of exchangeable cations including H and Al; P was extracted using the Bray No. 1 extractant and measured colorimetrically.

Experimental Results

Tuber yield. Tuber yield from the three locations as shown in Figure 2 was generally low, this was mainly due to the low plant density used (4444 plants/ha). At Ikenne,

tuber yield was higher, which reflects a better growing condition for yam, because of its higher annual rainfall (1600 mm) as compared to Ibadan (1270 mm). It was also noticed, that plants grown at the two sites in Ibadan scenesced earlier compared to those grown at Ikenne.

Although increasing heap size increased tuber yield at all three locations (Figure 2). There was a distinct effect of soil type on tuber yield in relation to heap size. The effect of heap size was less pronounced on the gravel free Alagba soil compared to those observed on the gravelly Egbeda and Ibadan soils. On the Ibadan soil site there was a significant effect of heap size on tuber yield (Table 6). Increasing heap size was also observed to be more pronounced with the fertilizer applied than plots without fertilizer application at all three locations.

There was no significant effect of NPK application on tuber yield at all three locations. There even appeared to be a depression in the tuber yield of the plants grown on flats at the Ibadan and Egbeda soil sites with fertilizer application. Despite the absence of any significant fertilizer response, there was a noticeable effect of fertilizer application on tuber yield, particularly with the large heap size treatment (Figure 2). The largest fertilizer effect was noticed on the Egbeda soil site ($>$ 1.6 tons/ha) followed by those grown at the Ibadan and Alagba soil sites.

Although there was no significant interactions between heap size X fertilizer application on tuber yield (Table 6), their combined effect in increasing tuber yields at the three locations was easily seen. This is better illustrated, by looking at the average tuber data in Table 3. With no fertilizer application, tuber yield was increased by only 14.4% when planting on flats was compared with the largest heap size, while with NPK application the average yield increase was 34.3%.

Tuber size and number. There was a positive effect of increasing heap size on tuber length (Table 4). This effect was more pronounced with fertilizer application. On the Egbeda soil site which showed the largest increase in tuber length with or without fertilizer application, the increase in tuber length was also observed to be significant (Table 6). The least effect of increasing heap size on tuber length was observed on the gravel free Alagba soil. Fertilizer application had no effect on tuber length of plants grown on the flat, but has a noticeable effect on plants grown on large heap.

Plants grown at the Alagba site showed higher tuber number per plant compared to those grown at the Ibadan and Egbeda sites (Table 5). Significant effects of increasing heap size and fertilizer application on tuber number were also observed on the Alagba site. The higher tuber number observed on the Alagba site, may contribute to the higher tuber yield at this location. There was no distinct effect of either heap size or fertilizer application on tuber number at the Ibadan and Egbeda sites.

Harvest time. The actual harvest time needed to harvest the tubers per plant increased with increasing yield/plant (data not included). Figure 3 gives the average harvest time needed to harvest one kg. of tuber. On the gravelly Ibadan and Egbeda soils, more time was needed for harvesting than on the gravel free Alagba soil. It is also clear, that the time needed to harvest the tubers from plants growing on flat or small heap was almost double those planted on the large heap. On the Ibadan soil which has a more gravelly subsoil it took more time to harvest the tubers from the medium heap size, because many of the tubers penetrated the subsoil making harvesting more difficult.

Nutrient composition of index leaves. The effect of heap size and fertilizer ap-plication on the composition of the index leaves of plants grown at the Alagba site is shown in Table 7. No distinct effect of heap size and fertilizer application was seen on the P, K, Ca and Zn percentages in the index leaves. With increasing heap size and

particularly with NPK application, there was an increase in the N level of the index leaves, indicating some N response at Ikenne. Application of NPK on the other hand depressed the Mn level of the index leaves.

Discussion

Although planting on the flat is practiced in river flood plains and on sandy soils (Coursey, 1967; Morgan, 1955; Owusu and Ofori, 1969), planting on the flat may result in lower yields than planting on mounds or ridges (Lal and Hahn, 1973). The importance of planting on large size heaps in order to obtain high tuber yield as compared to planting on the flat was also shown by the results reported in Figure 2. The effect of heap size on tuber yield was observed to be more pronounced on the gravelly Ibadan and Egbeda soils, which also have higher bulk densities in their subsoils (Table 2). Measurements of bulk densities of the large heaps for the Ibadan and Egbeda soils at 4 weeks after preparing the heaps showed lower values of 1.26 and 1.21 g/cc, respectively. On the gravel free Alagba soil, where there is little difference in the bulk densities of the surface and subsoils, the effect was almost much less. Planting on the flat on the Ibadan and Egbeda soils, resulted not only in smaller tubers, but also in mishappen and irregular shape tubers with less commercial value. Planting of yams with no-till system in these soils are therefore not recommended.

Gathering fertile soil from the surrounding area is mentioned as one of the advantages for heap making (Onwueme, 1978). If this is correct, this practice can be substituted for by addition of fertilizers. However, the results shown in Figure 2 do not support this assumption. The experimental sites were in the second and third years of cropping after fallow clearing and thus showed low levels of organic matter content (Table 1) and as expected N response was observed as indicated by the increase in N level of index leaves at Ikenne. Phosphate and K status at the three sites were adequate for yam. Yet application of NPK had no effect on tuber yield of yam grown on the flat at Ikenne, and even depressed yield on the Ibadan and Egbeda sites, indicating, that fertilizer addition cannot substitute for making heaps. The importance of fertilizer addition was only apparent when yam plants were grown on large heaps (Table 3).

It thus appears, that as long as traditional yam varieties are used, large size heaps are essential to provide a loose seedbed with low bulk density for the tuber to develop with little obstruction. Large size heaps are important both for obtaining high tuber yield and smooth, and long tubers (Tables 3, 4 and 5). Also important is the case of harvesting tubers from plants grown on large heaps as compared to those planted on the flat or on small heaps. This is clearly reflected by the shorter time needed to harvest from the large heaps (Figure 3).

It should also be pointed out, that damage during harvest was less on tuber from large heaps than from the flat which is a very important consideration in relation to storability of tubers.

References

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Table 1. Some properties of surface soils (0-15 cm) from experimental plots

Soil Series	Texture			pH	Org. C	Exchangeable cations					Total Acidity	Extrac. P.
	Sand	Silt	Clay	H_2O		CEC	Ca	Mg	K	Na	Mn	(A1 & H)	ppm.
	------- % -------				%	---------- me/100g ----------							
Ibadan	80	11	9	6.2	0.95	5.19	3.79	0.73	0.32	0.07	0.12	0.16	8.72
Egbeda	74	13	13	6.1	1.40	6.58	4.59	0.92	0.61	0.08	0.22	0.16	9.21
Alagba	80	9	11	6.0	1.03	4.55	3.19	0.92	0.12	0.06	0.18	0.08	12.50

Table 2. Bulk density surface (0-15 cm) and sub (15-30 cm) soils and gravel content of experimental sites

Soil depth	Soil series		
cm.	Ibadan	Egbeda	Alagba
	– – – – – Bulk Density (g/cc) – – – – –		
0 – 15	1.41 ± 0.14	1.45 ± 0.16	1.43 ± 0.07
15 – 30	1.68 ± 0.15	1.69 ± 0.06	1.46 ± 0.04
	– – – – – Gravel content (%) – – –		
0 – 15	12.5 ± 5.0	19.9 ± 3.16	No gravel
15 – 30	44.5 ± 21.7	35.1 ± 1.69	No gravel

Table 3. Effects of heap size and fertilizer application on average tuber yield across the three locations

Heap Size	No Fertilizer	+ Fertilizer
	tons/ha	
Flat	7.83 (69.3 %)	7.43 (65.7%)
Small heap	8.50 (75.2 %)	9.13 (80.8 %)
Medium heap	9.40 (83.1 %)	10.00 (88.5 %)
Large heap	9.46 (83.7 %)	11.30 (100%)

*Figures within brackets are percent yields expressed against yield observed with large heap and fertilizer application.

Table 4. Effect of heap size and fertilizer application on tuber length of yam cultivar Laoko

Treatment	Soil Series		
No Fertilizer	Ibadan	Egbeda	Alagba
		cm	
Flat	21.5	18.5	20.8
Small heap	22.4	18.9	22.5
Medium heap	25.4	24.6	23.9
Large heap	25.5	23.4	24.5
Average	23.7	21.4	22.9
+ *Fertilizer*			
Flat	20.9	18.3	19.6
Small heap	23.9	20.2	19.8
Medium heap	24.3	23.4	23.5
Large heap	27.0	27.9	25.4
Average	24.0	22.5	22.1

Table 5. Effect of heap size and fertilizer application on tuber number of yam cultivar Laoko

Treatment	Soil Series		
	Ibadan	Egbeda	Alagba
	Tuber number/plant		
	No Fertilizer		
Flat	1.84	1.49	1.86
Small heap	1.90	1.57	2.58
Medium heap	1.87	1.33	1.92
Large heap	1.89	1.42	2.17
Average	1.83	1.45	2.13
	+ *Fertilizer*		
Flat	2.01	1.60	2.58
Small heap	1.48	1.60	3.08
Medium heap	1.58	1.75	2.06
Large heap	1.63	1.44	2.17
Average	1.68	1.60	2.47

Table 6. Calculated F – values on effects of heap size and fertilizer application

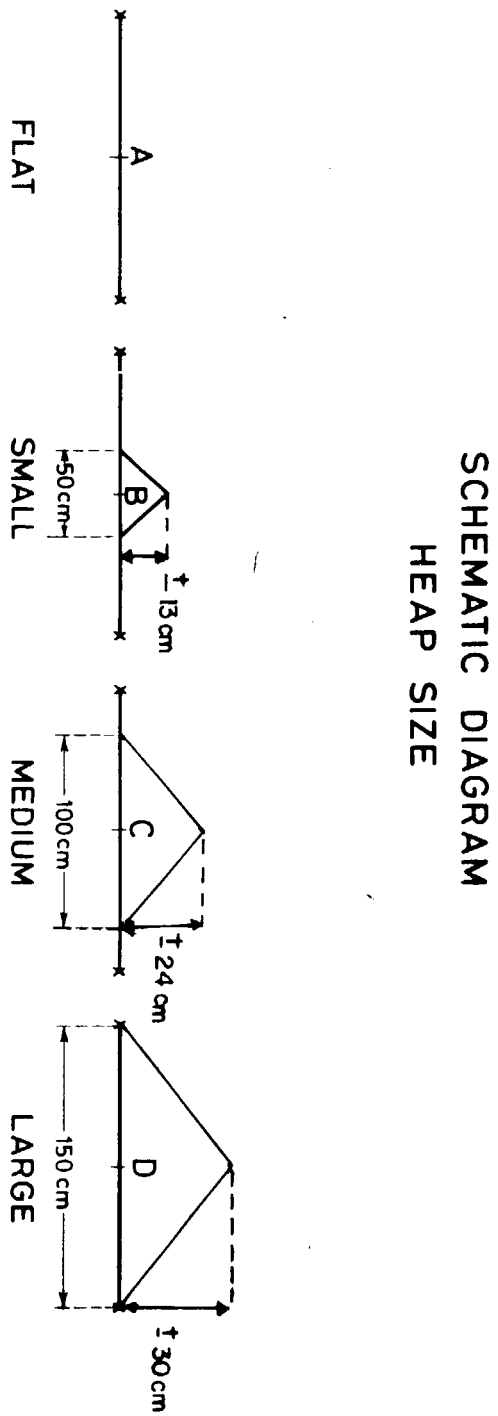
Treatment	Tuber yield	Tuber length	Tuber number
		Ibadan soil	
Fertilizer (F)	2.46	0.07	0.20
Heap size (H)	13.47**	2.86	0.48
F x H	2.18	0.37	0.44
		Egbeda soil	
Fertilizer (F)	0.05	0.41	2.11
Heap size (H)	6.94	17.38**	0.43
F x H	1.06	2.25	0.88
		Alagba soil	
Fertilizer (F)	0.38	0.74	22.37**
Heap size (H)	1.94	2.08	3.99*
F x H	0.20	1.25	0.81

** Significant at 1 % level

* Significant at 5% level

Table 7. Effect of heap size and fertilizer application on nutrient composition of yam index leaves, Alagba soil sites

Treatment	N	P	K	Ca	Mn	Zn
No Fertilizer	---------- % ----------				--ppm--	
Flat	2.23	0.17	0.85	2.89	360	26
Small heap	2.37	0.18	0.75	2.74	420	24
Medium heap	2.33	0.18	0.85	2.97	370	24
Large heap	2.40	0.17	0.66	2.93	360	24
Average	2.33	0.18	0.78	2.88	378	25
+ Fertilizer						
Flat	2.54	0.18	0.75	3.04	286	22
Small heap	2.53	0.17	0.94	2.83	390	18
Medium heap	2.48	0.16	0.86	2.89	270	20
Large heap	2.94	0.19	0.96	2.82	326	22
Average	2.62	0.18	0.88	2.90	318	21


SCHEMATIC DIAGRAM
HEAP SIZE
FLAT
A
SMALL
B
50cm
13 cm
MEDIUM
C
100cm
24 cm
LARGE
D
150 cm
30 cm

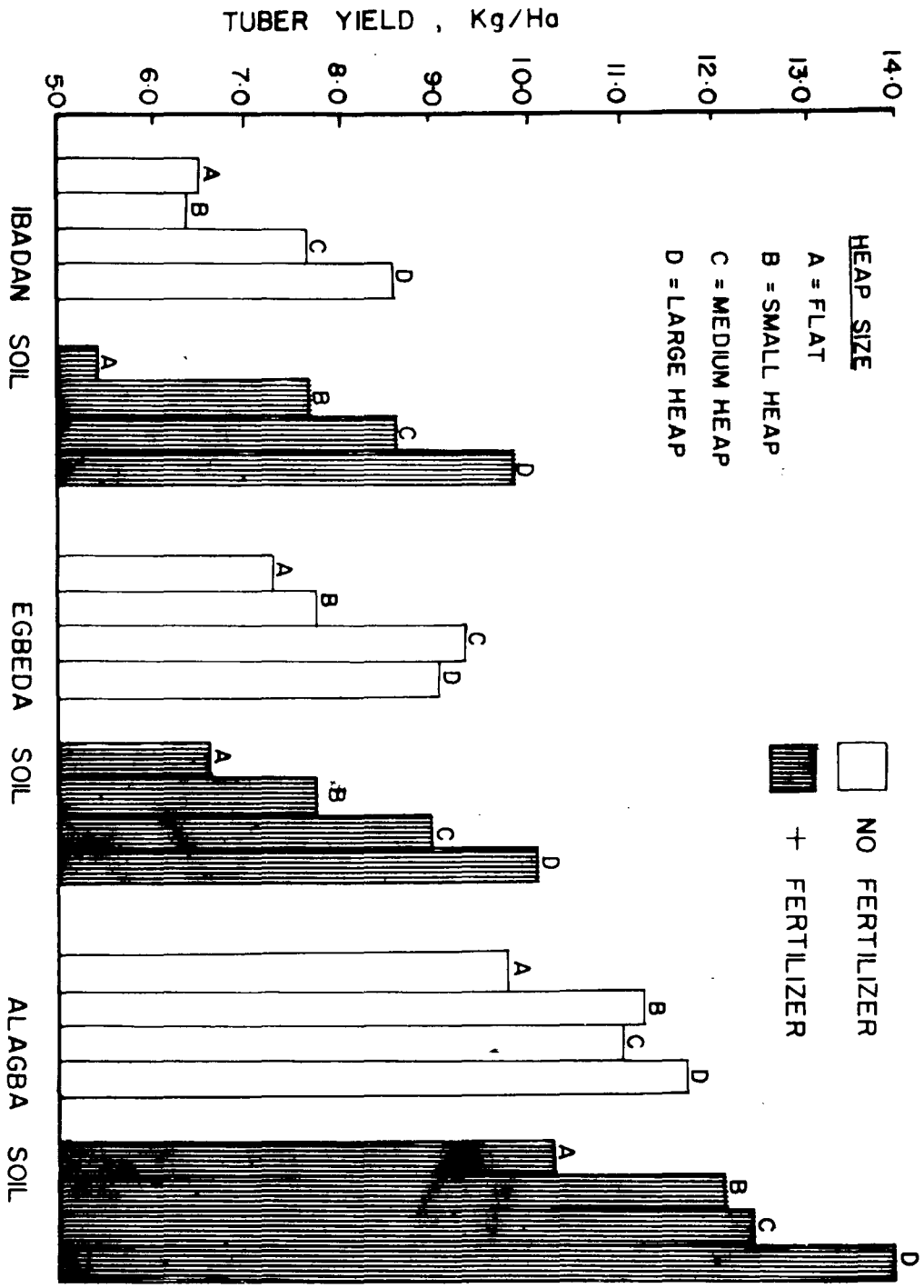


Fig. 2. Tuber yield yam cultivar Laoko at Three experimental sites as affected by heap size and NPK application.

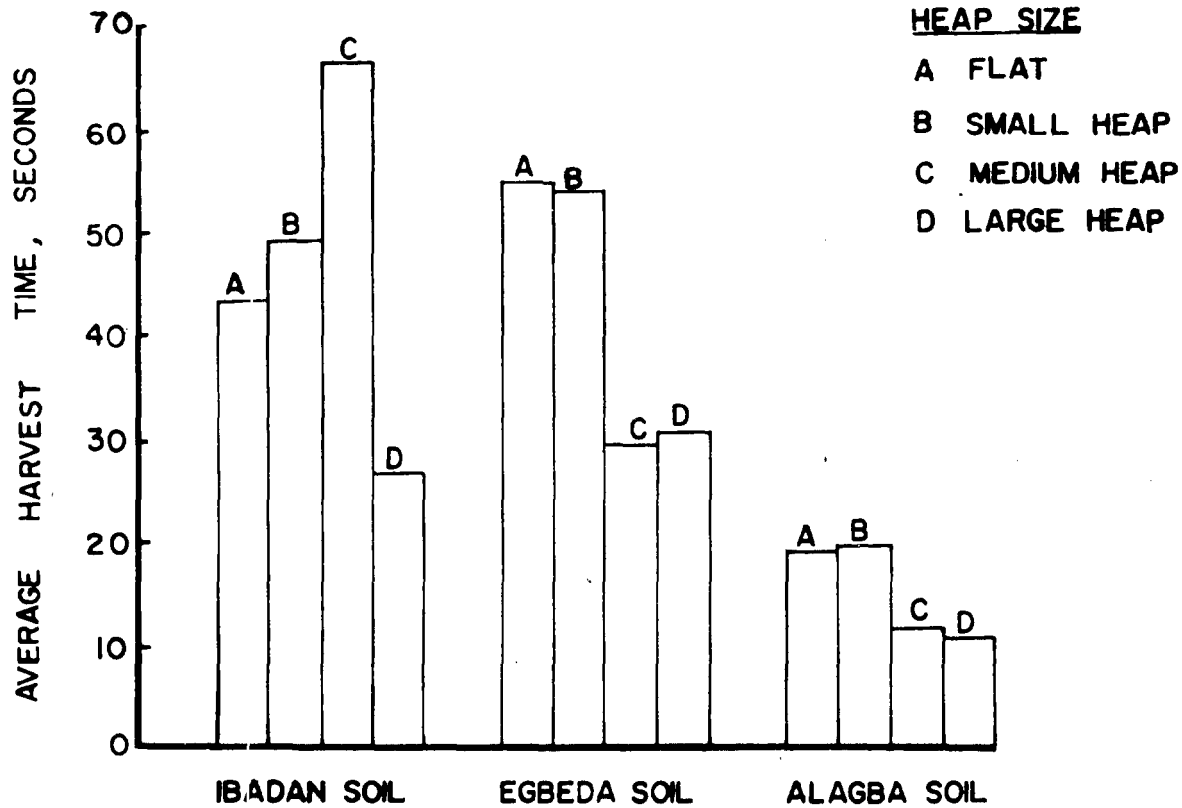


Fig. 3. Average harvest time (seconds/kg. tuber) required for harvesting at three experimental sites as affected by heap size.