

## DETERMINATION OF A BASIS FOR DESIGN OF A YAM (DIOSCOREA SPP.) MINISSETT SORTER

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### ABSTRACT

*It has been experimentally demonstrated that the practice of planting a mixture of yam minisett cut from the head, middle and tail portions of the tuber results in non-uniformity in sprouting and widely different germination rates and tuber yields. This problem could be overcome by separating the minisett into groups from the head, middle and tail portions of the parent tubers and planting them separately. Manual separation is both tedious and expensive, so the work reported here was done to determine a suitable basis for the design of a mechanical minisett sorter. Results from this study showed that the minisett cut from the regions of the parent tuber can be separated on the basis of characteristic dimensions of arc length or radius. This may provide a suitable basis for designing a mechanical sorter for yam minisett.*

### 1. INTRODUCTION

Yams are grown throughout West Africa where they serve as the major staple food, and in Nigeria yams constitute about 20% of daily caloric intake and almost the entire annual yam production is consumed as human food [1]. Ware yam production usually involves the use of whole tubers called "seed yams" that weigh between 100 and 1500g, or pieces cut from tubers called "setts" each weighing about 100g and used as planting material. Seed yams alone constitute over 40% of capital outlay in yam production [2]. Thus, to establish 1 ha of yams, may need as much as 3 t of seed yams. Very often the seed yam are not readily available as they may also be eaten, leading to scarcity and high cost of the planting materials. To overcome these difficulties and increase the supply of seed yams, the "minisett" technique of producing seed yams was developed [3].

With the development of the minisett technique, seed yam farmers are then offered a reliable and rapid method of large scale seed yam multiplication. A minisett is a yam sett of about 25g or less which is one quarter the normal planting sett of 100g for seed yam production and usually is about 2cm in thickness. Studies with minisett cut from the head, middle and tail portions of seed yam tubers have shown that minisett from the head region sprout earlier and achieve 50% germination before those from the

middle portions [3], [4]. Variations in the time of sprouting of the minisett are also reported to affect the development of transplanted propagules and this, in turn affects the total tuber yield [3].

Presently, minisett cut from yam tubers are planted without regard to the region of the parent tuber from which they were cut. This practice results in non-uniformity in sprouting and emergence [5], [3], wide variations in tuber yields at harvest and in the overall crop performance. It is therefore desirable to separate the minisett into groups from the head, middle and tail portions of the parent tubers and plant them separately in those groups. To achieve the separation manually is tedious and time consuming, especially where it is necessary to sort up to 40,000 minisett to plant one hectare. For this reason, a device to mechanically sort the minisett is needed.

The objective of this study was to determine a basis for the design of a mechanical sorter for yam minisett.

### 2. MATERIALS AND METHODS

#### 2.1 Physical Characterization of the Minisett

The yam tuber profile is shown in Fig. 1 and illustrates the nomenclature used to describe the minisett geometry. Two basic steps are involved in cutting seed yams into minisett. The first step

consists of cutting approximately 2cm thick sections (discs) perpendicular to the yam tuber axis. In the second step, each section is cut into four quarters along two perpendicular 'diameters' of the disc as shown in Fig. 1 c. Cut as described here, many of the resulting minisett pieces have a mass which differs widely from the recommended 25 g mass. A variation of up to 36% was reported by Muojekwu [6] for minisett cut from tubers of 7 cm average diameter and average moisture content of about 71 % (dry basis). However, it has been demonstrated that each resulting minisett has a viable mass and sufficient skin surface area to support germination and seed yam development. The yam minisett is shown in Fig. 1 d in its usual manual planting; orientation. However, orientation of the minisett does not affect its emergence, since any part of a healthy skin tubersurface is capable of yielding a sprout

when placed under favourable soil conditions [7]. Yam tubers are naturally circular in their transverse cross sections and this is true of the majority of the yam tuber species from which minisett are cut. Therefore, the physical properties considered relevant in the characterization of the yam minisett are the mass (M) and the linear dimensions of arc length (L), thickness (t) and radius (r) of the minisett as shown in Fig. 1 d. Thus minisett are quadrants of circular discs whose masses can be estimated as:

$$M = \frac{1}{4}(\rho Gr^2 t) \quad (1)$$

Where (Fig. 1d)

G = density of minisett  
 r = average radius of the yam  
 t = disc thickness

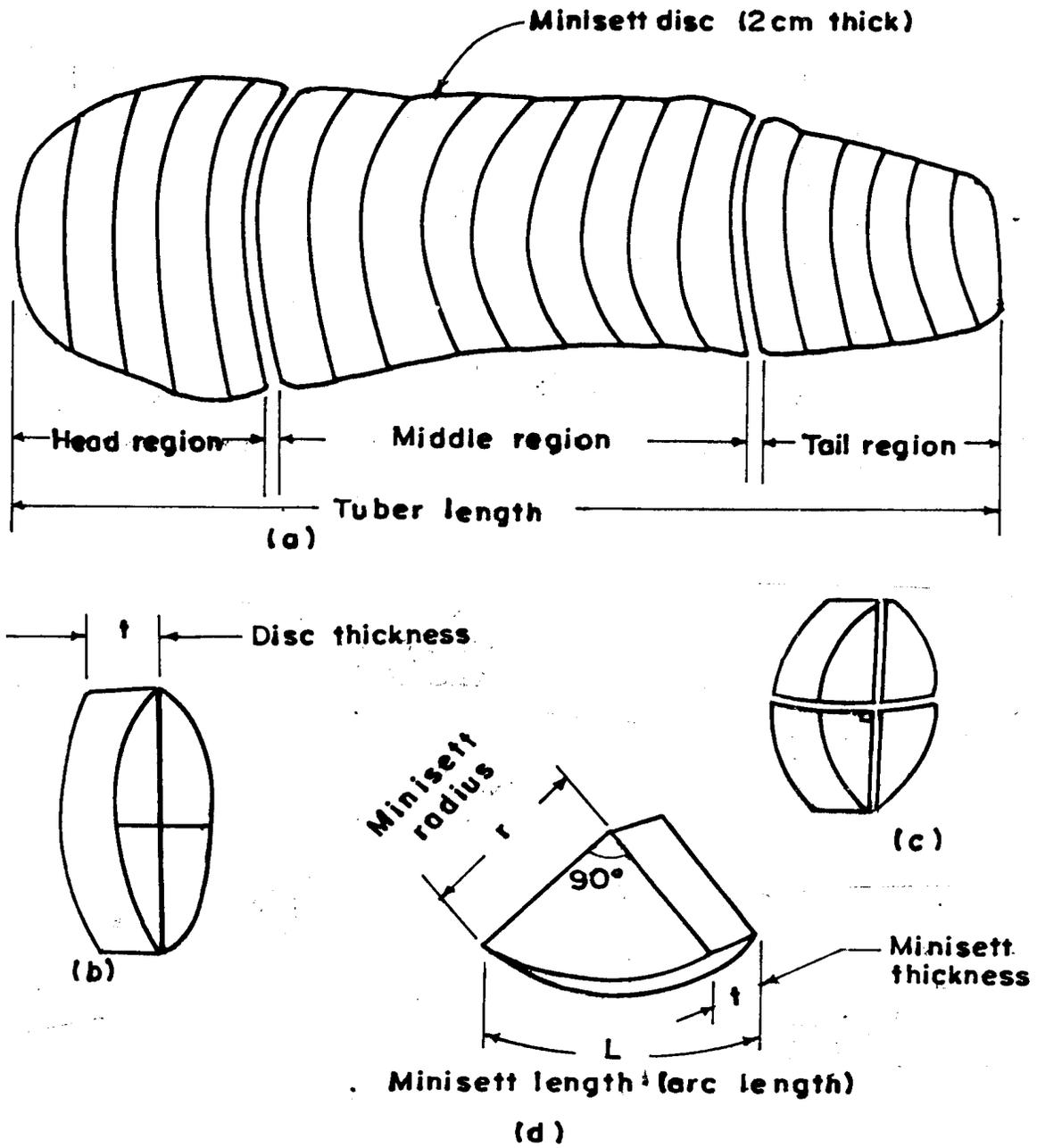


Fig. 1: Nomenclature used to describe yam minisett geometry.

(a) Yam tuber showing the three regions of cut;

(b) Yam minisett disc; (c) Four minisett (four quarters) cut from yam minisett disc;

(d) Yam minisett in usual planting position.

## 2.2 Methods

A total of 394 yam minisettts at an average moisture content of 61% dry basis were used. Out of this number 104,217 and 73 minisettts were cut from the head, middle and tail regions respectively of the parent tubers. The tubers used were of the specie *Dioscorea rotundata* and had average diameters varying from 6 to 8 cm. The steps described earlier were followed in cutting the tubers into minisettts, in accordance with the procedure of minisett preparation reported by Iwueke [8]. Each minisett was weighed with an electronic balance and its mass (M) recorded together with its location in the yam tuber. The skin surfaces were traced out on a graph paper with suitable scales to determine the arc length (L) of each minisett.

The other minisett dimensions of thickness (t) and radius (r) were measured with a vernier calliper. The water displacement method as outlined by Mohsenin [9] was used to measure the minisett volume (V) directly, but the minisettts were first smeared with yellow petroleum jelly to prevent absorption of water. With the measured values of t and r for each minisett, the volume was calculated as  $1/4\pi r^2 t$ . In order to verify that minisettts are quadrants of a circular disc, the measured masses were regressed against the calculated volumes for minisettts of each group using the Statgraphics regression analysis package. The analysis gave the coefficient of determination ( $R^2$ ) and also an estimate of the minisett density (g). The coefficient of variation (CV) was calculated and an F-test was performed to determine at what level of significance the minisett density was estimated.

## 3. RESULTS AND DISCUSSION

The estimated densities of the minisettts and the corresponding values of ( $R^2$ ) and (CV), together with the means of the masses and their standard deviations, obtained from the analyses, are given in Table 1 for minisettts from the head, middle and tail regions. The results showed that the densities of the minisettts depend on the region of the yam tuber from which they were cut, and were highest for the middle and lowest for the tail portions. The mean value of the estimated densities of the minisettts from all the regions of the tuber was  $1.04 \text{ g/cm}^3$  which is very close to

the average value of  $1.09 \text{ g/cm}^3$  determined directly by using the measured masses and volumes. It is also close to the value of  $1.07 \text{ g/cm}^3$  given by Egberi [10]. This validates the assumption of a circular cross-section for the yam tubers, and this finding is in agreement with that reported for Russet Burbank cultivar potato tuber by Marvin [11].

Table 1: Minisett density ( $\rho$ ), coefficient of variation (CV) and  $R^2$  values for minisettts by region of yam tuber.

Region of yam	Mean mass g	Standard deviation of mass b	$\rho \text{ g/cm}^3$	$R^2 \%$	C.V%
Head	12.72*	3.51	1.07	93.7	6.9
Middle	14.34*	3.33	1.20	94.2	5.4
Tail	9.59*	1.88	0.855	77.5	113

\* Significantly different at 5% level.

A one-way analysis of variance was done using the data on the masses of the minisettts from the three regions. As shown in Table 1, it was found that significant differences exist between the means of the masses. This suggests that separation of the minisettts into the different regions may be possible on the basis of their masses. But since means are generally not good estimators of the distribution of elements in a population, it was decided to study further the distribution of the masses. Histogram plots were drawn on the same scale using the statistical programme, and from the plots obtained it was difficult to show the distinction between them because they overlapped one another. To show the over lapping effect, distribution curves which closely approximate the histograms were drawn. Fig. 2 shows the histogram and its best-fit curve for the tail region. The distribution curves for the head and middle regions were drawn without the histograms from which they were got because of the reason already given. As shown in Fig. 2, the resulting curves clearly demonstrate that separation on the basis of minisett masses is not possible as there is a near 100% dilution of tail in the head and head in the middle minisett groups respectively.

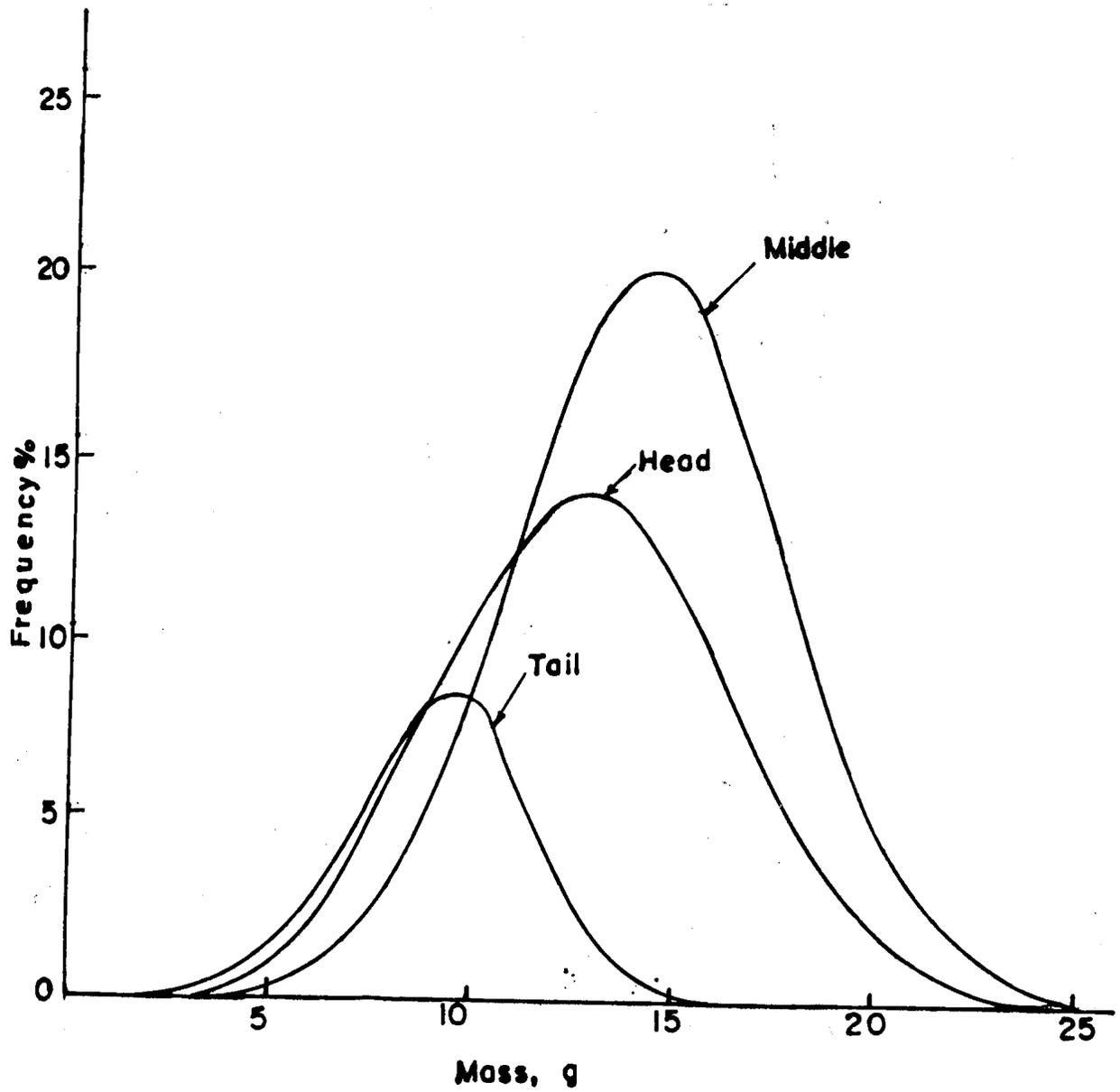


Fig. 2: Distribution plots of minisett masses from the tail, head and middle regions of yam rubers.

To find out if separation can be done based on a characteristic dimension of arc length of radius, a one-way analysis of variance was also done using the length and radius data for the three minisett groups. The results (Table 2) show that there are significant differences between the means of the lengths and radii of the different minisett groups, suggesting that separation based on the characteristic dimensions may be possible. For the same reasons given in respect of the masses and using the same Statgraphics programme, distribution curves which closely approximate the histograms of the dimensions L and r of the minisett from the three regions were plotted on the same scale to yield Fig. 3

and Fig. 4.

Table 2: Means of the lengths and radii of the minisett

Region of yam tuber	mean length cm	Standard deviation of arc length cm	Standard deviation radius cm
Head	4.80*	0.63	0.33
Middle	5.60*	0.60	0.38
Tail	4.20*	0.38	0.23

\* Significantly different at 5% level

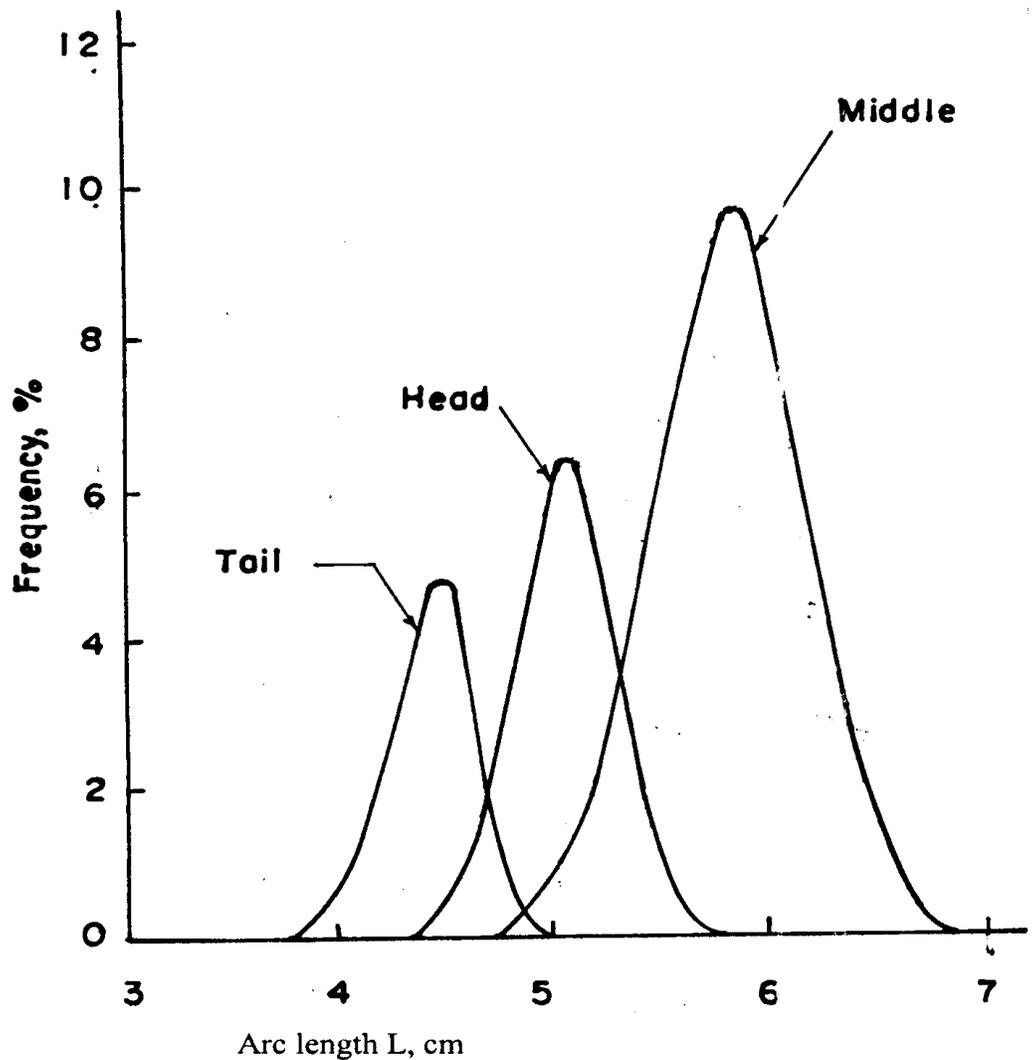


Fig. 3: Distribution plots of minisett lengths from tail, head and middle regions of yam tuber

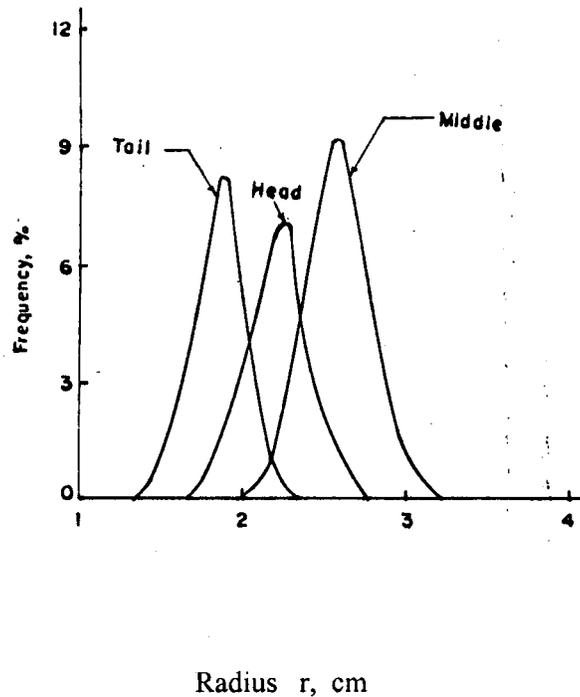


Fig. 4: Distribution plots of minisett radii from tail, head and middle regions of yam tubers.

The plots demonstrate that the minisetts can be separated on the basis of their arc lengths or radii. The percent overlaps calculated and presented in Table 3 also show that separation on the basis of characteristic dimensions arc length or radius is possible because of less overlaps in their distributions. However, the overlaps of middle in the head for the arc length and the radius are as high as 25% and 20% respectively. But since it has been shown that the minisetts from the middle perform most poorly in terms of sprouting [3], [4]; the achievement of at least 75% separation of the middles from the rest should improve the performance of planted fields substantially. Therefore, minisett dimensions will provide an acceptable basis for the design of a mechanical sorter for yam minisett. Practical applications of the results of this study appear feasible because it is usually easier to sort by differences in dimensions rather than differences in mass.

Table 3: Percent overlaps of the distributions of the minisetts based on their characteristic dimensions.

Overlapping distribution	Characteristic Arc length	Dimension Radius
Tail in head	8	5
Head in tail	6	5
Tail in middle	2	3
Middle in tail	7	8
Head in middle	18	15
Middle in head	15	20

#### 4. CONCLUSIONS

1. Although there are significant differences between means of masses of minisetts from head, middle and tail regions, it is not possible to achieve their separation into the respective groups on the basis of their masses because of the overlap of their distributions.
2. An acceptable degree of separation of

minisetts into head, middle and tail groups can be based on their characteristic dimension of arc length or radius. This offers a potential method on which to base the design of a mechanical sorter for yam minisetts.

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