The Effect of Sett Size, Sett Type and Spacing on Some Aspects of Growth, Development and Yield in White Lisbon Yams (*D. alata* L.)

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ABSTRACT

The effect of three sett sizes (85, 170 and 355 g), two sett types (heads and middles), and two spacings (90x30 cm and 90x60 cm) were examined in a factorial experiment with white Lisbon yam (*D. alata* L.) on a loam soil in Trinidad. Tuber yield increased with increasing size of middle setts but did not increase for head setts, which seem to be more efficient than middle setts. Small head setts yielded as well as large head setts at both close and wide spacings. The overall results suggest an asymptotic response in yield to increasing seed rate in white Lisbon yam. The greater yield of large setts seems to be related to a longer duration of rapid tuber bulking, resulting primarily from earlier and more rapid tuber bulking during the earlier period of tuber development.

Introduction

A number of workers have shown that in Yams (*Dioscorea* spp.) sett size affects growth (Enyi, 1972; Onwueme, 1972) and yield (Miege, 1957; Baker, 1964; Afonja, 1967; Enyi, 1972, Onwueme, 1978). In general, yield tends to increase with increasing sett size. Larger setts emerge earlier, produce greater plant dry weights and higher mean tuber bulking rates. Head setts of yams have also outyielded middle and tail setts but some workers have found no difference in yield due to sett type (Waitt, 1959; Gooding and Hoad, 1967). Yield in yams has increased with increasing plant density (Wood, 1933; Baker, 1964; Gooding and Hoad, 1967; Afonja, 1967; Henry, 1967; Caro-Costas and Servando, 1968; Enyi, 1972).

The effect of sett size and spacing can be jointly considered to be one of seed rate, i.e. the total weight of setts material planted per unit area of land. Baker (1964) examined the effect of seed rate on the yield in *D. rotundata* Poir, and found that an asymptotic curve for yield at increasing seed rates was only obtained when sett weight (size) was constant and seed rate was proportional to population. Afonja (1967) in an experiment with *D. rotundata* found that yield increased linearly with increasing seed rate but the yields obtained were very low (average 5.3 tons/ha.). Henry (1967), working with *D. trifida* L. found that sett size had a small effect on yield but spacing had a marked effect.

It is the object of this experiment to study the effect of sett size, sett type and spacing and their interactions on growth, particularly tuber growth, and yield in "White Lisbon" yams (*D. alata* L.) with a view to understanding some of the crop physiological processes affecting yield.

Materials and Methods

Three sett sizes, two sett types of *D. alata* in White Lisbon and two plant densities were investigated in factorial combinations in this study. The main treatments were:

Sett sizes	(1)	85 gm (small)
	(2)	170 gm (medium)
	(3)	255 gm (large)
Sett types	(1)	Heads (i.e. setts taken from the part of the tuber proximate to the vine)
	(2)	Middles (i.e. setts taken from the central portion of the tuber)
Spacing	(1)	90x30 cm - 35880 plants/ha (close)
	(2)	90x60 cm - 17940 plants/ha (wide)

The experiment was on the University Field Station, Trinidad, on River Estate Loam soil type, which is of moderate fertility. The field was in grass and uncultivated for the previous 4 years was in the form of a low camber. The soil was prepared for planting by ploughing to a depth of 20 cm. It was then rotavated and formed into ridges 90 cm apart.

Setts were planted at a depth of 9 cm on the crest of the ridges. The pre-emergence herbicide, atrazine, was applied at the rate of 3.4 kg per ha on the 28th May. Subsequent weed control was done by hand. Plants were staked one month after planting using individual bamboo poles 1.6 m long. Fertilizer was applied at planting as 373 kg per ha each of muriate of potash and triple super phosphate and 3 months later as 314 kg per ha of sulphate of ammonia. Plants were sprayed alternately with Dithane M45 at 1.5 kg per ha and Miltox at 1.1 kg per ha every 2 weeks for control of an anthracnose disease which attacks leaves and stems.

The number of plants emerging was recorded weekly up to the 8th week after planting. Three complete plants for growth analysis determination were harvested from each plot at three weekly intervals from the 7th to the 19th week after planting.

Analysis of the growth of the foliage was discontinued after the 19th week because of difficulty in recovering the foliage due to entanglement of sample plants with neighbouring guard and other sample plants. Stem number and tuber development were monitored after the 19th week regular samplings at approximately three weeks intervals.

Results

Tuber Yield

Tuber yield increased with increasing sett weight (Table 1). However, this increase in yield occurred with middle setts only; small setts of middles produced a significantly lower tuber yield than large setts of middles and all setts of heads. No significant differences were observed among the sett sizes used for heads. At the wide spacing middles produced a significantly lower yield than heads at the wide spacing or middles and heads at the close spacing. Small setts at the close spacing produced a significantly lower yield than large setts at both the wide and close spacing.

Table 1. The mean effect of sett size, sett type and spacing on yield in "White Lisbon" yam (*D. alata* L.).

	Head Setts	Middle Setts	Close Spacing	Wide Spacing	Mean
			tons/ha		
Small setts	37.7a	31.6b	36.2ab	33.0b	34.6b
Medium setts	36.7a	35.6ab	37.3ab	35.0ab	36.1ab
Large setts	38.1a	39.2a	39.0a	38.3a	38.7a
Close spacing	37.7a	37.4a	-	-	37.5a
Wide spacing	37.3a	33.6b	-	-	35.4a
Mean	37.5a	35.5a	37.5a	35.4a	36.45

For heads increasing seed rate above the minimum used (1,525 kg/ha) did not lead to an increase in total yield. As a result net tuber yield (i.e. total tuber yield less the weight of setts planted) declined with increasing seed rate. For middles, however, there was a marked increase in yield with the increase in seed rate and the relationship tended to become asymptotic at higher seed rates. Net tuber yield increased up to about 4,500 kg/ha for middles and declined thereafter.

Sett size and sett type had no significant effects on tuber number per plant. The yield differences resulting from these two varieties were therefore primarily due to differences in tuber size (Table 2). Small setts of middles which were relatively lower yielding produced a larger proportion of small and unmarketable tubers. Plants grown at the wide spacing produced a significantly greater number of tubers per plant and also larger tubers than those grown at the close spacing. Tuber number per unit area was, however, greater for plants at the closer spacing (239 vs 178, $p = 0.01$) resulting in little difference in tuber yield between the close and wide spacings.

Aerial tubers

The first visible signs of aerial tuber formation were observed between 25 and 28 weeks after planting. Very rapid development of these tubers was noted thereafter. The effects of the various treatments on the production of bulbils are presented in Table 3. Large and medium size setts produced a greater yield of aerial tubers than small setts. Differences between the two sett types and the two spacings were not significant although yields appeared to be higher for heads and at the wide spacing. The higher yield of aerial tubers from large setts was due to both the production of larger and greater numbers of tubers.

Time to emergence

Plants from head setts emerged earlier than those from middle setts and those from large setts emerged earlier than those from small setts. Plants from large head setts emerged earliest and those from the middle setts latest.

Table 2. The mean effect of sett size, sett type and spacing on tuber number per plant in "White Lisbon" yam (*D. alata* L.).

	Head Setts	Middle Setts	Close Spacing	Wide Spacing	Mean
	tubers/plant SE ± 0.91		tubers/plant SE ± 0.91		tubers/plant SE ± 0.65
Small setts	2.67	2.84	2.20	3.30	2.75
Medium setts	2.65	2.83	2.22	3.26	2.74
Large setts	2.84	2.66	2.20	3.30	2.75
	SE ± 0.75				SE ± 0.53
Close spacing	2.11	2.31	-	-	2.21
Wide spacing	3.34	3.25	-	-	3.29
	SE ± 0.53		SE ± 0.53		
Mean	2.72	2.78	2.21	3.29	2.75

CV = 66.2%

Table 3. The mean effect of sett size, sett type and spacing on aerial tuber production in "White Lisbon" yam (*D. alata* L.)

	Head Setts	Middle Setts	Close Spacing	Wide Spacing	Mean
	kg/ha SE ± 0.94		kg/ha SE ± 0.94		kg/ha SE ± 0.66
Small setts	242	197	224	215	220
Medium setts	457	383	388	453	421
Large setts	527	410	422	516	469
	SE ± 0.77				SE ± 0.54
Close spacing	405	284	-	-	345
Wide spacing	413	376	-	-	394
	SE ± 0.54		SE ± 0.54		
Mean	409	330	345	394	370

CV = 50.9%

Total dry weight and stem numbers

During the 19-week period when foliage was analysed larger setts produced larger plants than small and medium setts. Plants from head setts had significantly greater dry matter than those from middles at 7 and 10 weeks after planting. Differences in total dry weight due to spacing were observed after the 10th week; plants grown at the wider spacing had a greater total dry matter than those at the closer spacing.

Tuber development

Large setts produced greater tuber dry weights at all sampling dates and this resulted in a higher yield for large setts. The relative differences in tuber development between large and small setts were greater during the earlier period of growth. The higher tuber yield of large setts seem to result from higher bulking rates during the period 13th to 22nd. The bulking rate declined rapidly after 32 weeks for all sett sizes. However, the bulking rate for small setts seems to decrease at a slightly slower rate than large setts but this does not appear to have compensated for the slower rate of bulking before the 22nd week. Large setts therefore appear to have a longer period of more rapid tuber bulking than small setts and this may have resulted in the greater yield for large setts.

Plants grown at the wide spacing accumulated dry matter in their tubers at a greater rate and for a slightly longer period than those at the close spacing and this accounted for the higher per plant yield at the wide spacing. Unlike the effect of sett size the differences between spacing treatments were more pronounced during the 22nd and 32nd week.

Plants from large setts produced significantly fewer tubers than other setts during the period of rapid tuber bulking but differences had disappeared by final harvest. Spacing had a large effect on tuber number with plants at the wide spacing producing a significantly greater number of tubers from 16th week onwards.

Discussion

Although tuber yield increased with increasing sett size the effect was confined to middle setts only, particularly at the wide spacing. Head setts seem to be more efficient with small setts yielding as well as large setts at both close and wide spacings.

The results of this experiment indicate an asymptotic response in yield to increasing seed rate for *D. alata* which agrees with the results of Baker (1964) for *D. rotundata*. Very much lower seed rates are required for heads as compared to middles. The results show that the yield response curve was already at its maximum for the lowest seed rate (1,525 kg/ha) used for heads in this experiment with the result that net yield declined with increasing seed rate. For middle setts the biological optimum seed rate as indicated by the maximum net yield is about 4,500 kg/ha which means that at least three times the quantity of middle setts are required to get a yield equivalent to the lowest seed rate used for heads.

In Trinidad the normally recommended seed rate is about 2,500 kg/ha of mixed setts (Haynes, 1967). It is suggested that in commercial cultivation head setts should best be separated from middles and that the seed rate of each adjusted by varying either spacing and/or sett weight.

The higher tuber yield of large setts and head setts seems to be related to the earlier emergence and the more rapid early growth of plants developing from these setts. Large setts will contain a greater quantity of dry matter and nutrients than small setts and it has been shown by Ferguson et al. (1980) that head setts contain greater concentration of dry matter, N, P, Ca, and Mg and therefore greater quantities of these nutrients than middle setts. It seems likely that the amount of carbohydrates and nutrients available in the sett for mobilization to the developing plant can affect the growth of these plants and yield. It is also likely that one or more of these factors affect the size of the primary nodal complex which develops directly from the sett and so determine the size of the tuber sink.

The greater yield for large setts seems to be related to a longer duration of rapid tuber bulking resulting primarily from earlier and more rapid tuber bulking during the earlier period of tuber development. Enyi (1972) related the higher yield of large setts in D. esculenta to higher mean bulking rates over the tuber bulking period and Bremner and Taha (1966) found that in the potato the higher yield of large setts resulted from a longer bulking duration because of earlier tuber initiation. The earlier emergence and earlier and longer, more rapid tuber growth of large setts suggest that tubers may be initiated earlier in the large setts of D. alata.

A greater number of tubers was produced and apparently resorbed for small and medium setts than for large setts. Sett size had no effect on the number of tubers produced at final harvest and yield differences were therefore only as a result of differences in tuber size. However, it seems possible that the early formed tubers of large setts were greater sinks than the later formed tubers, thus giving early formed tubers a competitive advantage for bulking assimilates over later formed tubers, the development of which was apparently suppressed.

Unlike the effect of sett size the higher per plant yield at the wide spacing resulted from both an increase in the number and size of tubers. Bulking rate per plant was markedly higher at the wide spacing and was maintained for a slightly longer time. Closer spacing seems to lead to earlier cessation of formation of new tubers and also to earlier resorption of tubers as maximum tuber number was achieved 10 weeks earlier than at the wide spacing.

Aerial tubers in D. alata are secondary sinks and account for a relatively small proportion of the dry matter stored in tubers, in this experiment only one percent. They, however, have agronomic potential for use as planting material because they can be high yielding (Ferguson et al., 1969) and are easy to harvest, simple to prepare for planting, free from cut surfaces that can lead to pathogenic infection and free from pathogenic soil microorganisms. The possibility of developing a system to increase production of aerial tubers needs investigation.

Aerial tubers appeared on vines just after the period of greatest tuber bulking was achieved. Sawada et al (1958), working with D. opposita Thunb. found that high sugar concentration was necessary for the formation and growth of aerial tubers but not for tuberization. A build-up in the concentration of sugars in the stems of yams after the 25th week could have led to the development of aerial tubers. The tuber is a blunt and voluminous organ and Ferguson and Gumbs (1976) have demonstrated that soil compaction can restrict its growth. The tuber grows against existing soil resistances and with the increasing size of the tuber these resistances become greater and restrict the development of the tuber which can result in a build-up in assimilates, mainly sugars, in the translocatory system, which may trigger aerial tuber formation and growth. The higher yield of aerial tubers from large setts could be partly accounted for by the earlier physical restriction of the growth of the larger developing tubers from large setts.

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