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Research Article

Effect of Pot Size and Transplanting Date on Tuber Production Using Micro-Tubers of White Yam

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Abstract
Low multiplication ratio, long growth and development duration contribute to the long conventional breeding cycle of yams. Moreover, little is known about the effect of pot size and transplanting date on the yield of introduced semi-autotrophic hydroponics (SAH) derived micro-tubers of white yam (*Dioscrea rotundata* Poir). This study was carried out to evaluate the effect of pot size and transplanting date on tuber production of introduced SAH micro-tuber derived white yam var TDr9719177 in shed-house conditions. The SAH materials were introduced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The trial involved two factors including two different pot sizes (38.5×28.5cm and 29.5×23.0cm) and two transplanting dates (September, 2020 and October, 2020). The results showed that micro-tubers grown in the big pot (38.5×28.5cm) significantly out yielded those established in the small pot (29.5×23.0cm). Transplanting in September produced heavier fresh tubers per plant (123.4g) and fresh tuber weight per tuber (88.8g) than transplanting in October, which had 17.4g and 14.1g, respectively. The mean difference of fresh tuber weight per plant between the transplanting pots was 68.4%, and between the transplanting dates was 85.9%. The mean difference of weight per tuber between the transplanting pots was 74.2%, and between the transplanting dates was 84.1%. The results suggested the relevance of early transplanting of healthy seedlings from SAH derived micro-tubers that could be exploited for deployment and promotion to seed yam producers for increased yam productivity. It also depicted the relevance of transplanting SAH micro-tubers in big container that promotes higher tuber production that could be exploited for the rapid multiplication of early generation seeds in yam breeding.

Keywords: pot size, planting date, semi-autotrophic hydroponics, mini-tuber production, white yam

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1 INTRODUCTION

Yams (Dioscorea spp.) are grown in Africa, Asia, parts of South America, as well as the Caribbean and the South Pacific islands[1]. In West Africa, 45 million tons of yams are produced annually on 4 million hectares of arable land[1]. Yam (Dioscorea species of family Dioscoreaceae) is an important crop for food, income, and medicine[2]. It plays a significant role in social and cultural events, and is the food of choice at many ceremonies and festivals[3]. Yams are a major source of calories for over 300 million people in the tropics and subtropics[4]. Unfortunately, recent economic developments and population growth are threatening global food security.

Despite its importance, the multiplication ratio of yam is very low, estimated at less than 1:10 using the conventional propagation systems (tuber or seed-sett)[5]. The low multiplication ratio and long growth and development duration contribute to the long conventional breeding cycle of yams estimated at about 8 to 10 years[6]. Moreover, the low multiplication ratio of the crop causes farmers a high proportional investment of their production costs on planting material. Thus, effective, accelerated, and massive distribution of new yam genotypes with desired traits including high yield, disease tolerance, and early maturity, etc., require the improvement of the multiplication ratio of yam.

In the traditional yam production cropping system, farmers reserve about 30% of their harvest, often from small whole tubers or by cutting large tubers into small setts weighing 150-1000g as seed tuber for the next planting season[7]. The International Institute of Tropical Agriculture (IITA) and National Root Crops Research Institute (NRCRI) have jointly developed the yam minisett technique (YMT) to improve seed tuber production. The YMT requires the cutting of tubers into 25-30g sett weights called minisetts. The biggest seed tubers produced from the YMT may reach up to 1kg at 5-6 months after planting[8]. However, the sprouting and fresh tuber yield obtained in the field are strongly influenced by genotype in white yam (*D. rotoundata*), which makes the irrigation of the crop during the early growth stage imperative[9].

Recently, a novel, robust, more efficient and low-cost technology known as the Semi-Autotrophic Hydroponics (SAH) has been developed for rapid and high-ratio propagation of clonal or vegetatively propagated crops. The SAH technique involves the establishment of nodal cuttings from true-to-type, and virus-free yam planting materials from tissue culture in transplanting boxes containing a mixture of subtrate and growth nutrient medium. It is a licensed technology developed in Argentina and transferred to IITA, Ibadan, Nigeriain April 2017. The SAH technique has the potential of producing 720,000 plants per year, with less than 2% plant loss and little contamination. The SAH technology complements other existing propagation methods to meet the growing seed yam demand in West Africa.

The effects of planting pot and planting date on tuber production have been demonstrated in a typical root and tuber crop such as potatoes. According to Bandara et al.[10] larger pots greater than 15cm depth promoted potato biomass production, thereby supporting more fresh weight, enhanced plant growth and higher tuber production. Moreover, transplanting pot materials may be expensive depending on the types of materials used. Availability, affordability and accessibility to the type of transplanting materials desired might limit their use. For yams, little is known about the effects of growing yam seedlings in different pot sizes and transplanting dates on tuber production. Such knowledge is needed for increased production and management of seed yam. The aim of this study was to evaluate the effects of pot size and transplanting date on tuber production of white yam using SAH micro-tubers.

2 MATERIAL AND METHODS

2.1 Planting Material, Experimental Design and Layout

The experiment was conducted during 2020-2021. Semi-autotrophic hydroponics (SAH)-derived micro-tubers of white yam (*Dioscrea rotundata* Poir var TDr9719177) introduced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria were used in this experiment.

The experiment was laid out in a 2×2 factorial arrangement in complete block design. The two factors were pot size and transplanting date. The levels of pot size included 29.5×23.0cm and 38.5×28.5cm. The levels of transplanting date consisted of September and October.

2.2 Planting, Transplanting and Agronomic Management

The SAH micro-tubers of genotype TDr9719177 were nursed in holes created in coco peat substrate (horticoco) placed in perforated seedling trays on September 3rd, 2020 (Figure 1). The plants were irrigated to field capacity as required to maintain adequate moisture levels that supported sprouting and growth. The first set of seedlings that comprised of about half the seed lots sprouted were transplanted on September 26th, 2020 and the second set was transplanted on October 26th, 2020, in organic soil placed in perforated polyethylene bags. Prior to transplanting, each perforated polythene bag (pot) was filled with sterilized topsoil and irrigated to field capacity. The seedlings were transplanted in holes created in the crest of the sterilized topsoil and irrigated to field capacity every three days until six months after transplanting (MAT). The spatial distance between and within blocks was 0.5m apart. The growing seedlings of each set were fertigated one month after transplanting (MAT) at the rate of 50g 15:15:15 (N:P:K) per 1L of water. The trial was harvested at six MAT.

2.3 Data Collection

The data was collected on tuber production using the sensitive electronic scale balance. This parameter was used to estimate the weight of tubers per plant (pot) and the weight per tuber for the various treatments used.

2.4 Statistical Analysis

The data collected were analyzed in GenStat version 16 statistical package[11]. The least significant difference (LSD) was used to compare treatment means at the α=0.05 level of significance. The residuals of data for the parameters

Figure 1. Photographic display of SAH micro-tubers nursed in holes created in coco peat medium placed in perforated seedling trays.

were first checked for normality and homogeneity using the Shapiro-Wilk test and Bartlett's test to ensure that data were normally distributed.

3. RESULTS AND DISCUSSION

3.1 The Effect of Pot Size on the Mini-Tuber Production

Pot size significantly (P<0.001) influenced yam mini-tuber production (Tables 1 and 2; Figure 2). Yam seedlings transplanted in pots measuring 38.5×28.5cm significantly (P<0.001) produced heavier fresh tuber per plant (0.1071kg or 107.1g) and weight per tuber (0.0818kg or 81.8g) than those transplanted in 29.5×23.0cm pots, which had 33.8g and 21.1g, respectively. The mean percent difference in fresh tuber per plant between the 29.5×23.0cm and 38.5×28.5cm transplanting pots was 68.4%. Both pot sizes consistently exhibited increasing fresh tuber weight per plant of 86.2% and 85.8%, respectively, across the two transplanting dates. Similar trends are observed for fresh tuber weight per tuber, which had percent mean difference of 74.2% between the small and big pot sizes used (Table 1). These findings are consistent with the view that plants grown in large pots exhibit higher tuber production than those grown in small pots[10,12,13].

3.2 The Effect of Planting Date on the Mini-Tuber Production

Transplanting dates significantly (P<0.001) influenced mini-tuber production in SAH derived micro-tuber white yam (Table 1 and Table 2; Figure 2). Transplanting in September significantly (P<0.001) produced heavier fresh tuber per plant and fresh tuber weight per tuber compared to transplanting in October. Transplanting in September exhibited significantly higher mean fresh tuber weight per plant of 0.1234kg (123.4g) and weight per tuber of 0.0888kg (88.8g) than transplanting in October, which had mean values of 0.0174kg (17.4g) and 0.0141kg (14.1g), respectively. The mean percent increase between transplanting in September and October was 85.9% and 84.1% for fresh tuber weight per plant and weight per tuber, respectively. Both transplanting dates consistently exhibited increasing fresh tuber weight per plant of 68.3% and 69.3%, and weight per tuber of 74.9% and 69.6%, respectively, across the two different pot sizes (Table 1).

Findings indicated that early transplanting of sprouted micro tuber plants increased the effective crop growth duration that supported tuber production, whereas delayed transplanting due to delayed sprouting led to significant reduction in tuber production. These results are consistent with the view that transplanting date influences mini-tuber production in tuber crops[10,13-15]. In potatoes, for instance, Opoku-Ameyaw and Harris[16] found that the total mini-tuber yield was significantly higher in the first planting date than those established in subsequent planting dates. In yams, planting date, good sprouting, vigorous establishment and healthy growth are key índicators that contribute to selection of elite genotypes for tuber production in white yam[17]. Findings of the present study are also consistent with the view that the establishment rate depends partly on the early sprouting and its healthy vigorous growth[7].

4 CONCLUSION

This study established that transplanting of early sprouted semi-auto trophic hydroponics micro-tubers could be exploited for increased seed yam tuber production. The use of big transplanting pot that supports tuber growth and development could be exploited for increased seed yam tuber production and rapid multiplication of early generation seeds in yam breeding. Findings are relevant to seed yam producers, breeders and other scientists for deployment and promotion of putative elite varieties for release.

Table 1. Mean Tuber Weight Per Plant (kg) and Weight Per Tuber (kg) of White Yam (Var TDr9700917) Grown in Two Pot Sizes and Two Different Planting Dates

Fresh Tuber Weight Per Plant (kg)				
Pot Size	Planting Date		Mean	Difference (%)*
	September	October		
29.5 × 23.0cm	0.0594	0.0082	0.0338	86.2
38.5 × 28.5cm	0.1875	0.0267	0.1071	85.8
Mean	0.1234	0.0174	0.0704	85.9
Difference (%)*	68.3	69.3	68.4	
$LSD_{(5\%)\ PS}$	0.00959			
$LSD_{(5\%)\ PD}$	0.00959			
$LSD_{(5\%)\ PS \times PD}$	0.01356			
CV(%)	9.6			

Fresh Tuber Weight Per Tuber (kg)				
Pot Size	Planting date		Mean	Difference (%)
	September	October		
29.5 × 23.0cm	0.0356	0.0066	0.0211	81.5
38.5 × 28.5cm	0.142	0.0217	0.0818	84.7
Mean	0.0888	0.0141	0.0515	84.1
Difference (%)*	74.9	69.6	74.2	
$LSD_{(5\%)\ PS}$	0.01473			
$LSD_{(5\%)\ PD}$	0.01473			
$LSD_{(5\%)\ PS \times PD}$	0.02083			
CV(%)	16.9			

PD=planting date; LSD=least significant difference; CV=coefficient of variation; *=percent differences between the two transplanting dates and the two transplanting pot sizes.

Table 2. Analysis of Variance (ANOVA) of Weight Per Plant (kg) and Weight Per Tuber (kg)

Weight Per Plant (kg)					
Source of Variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	2	0.0005775	0.000289	6.27	
Rep.*Units* stratum					
Pot size	1	0.01612437	0.016124	350.16	<.001
Plndate	1	0.03370682	0.033707	731.99	<.001
Pot size. Plndate	1	0.00902069	0.009021	195.9	<.001
Residual	6	0.00027629	4.61E-05		
Total	11	0.05970568			

Weight Per Tuber (kg)					
Source of Variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	2	0.0006059	0.000303	2.79	
Rep.*Units* stratum					
Pot size	1	0.0110724	0.011072	101.83	<.001
Plndate	1	0.0167433	0.016743	153.98	<.001
Pot_size. Plndate	1	0.0062477	0.006248	57.46	<.001
Residual	6	0.0006524	0.000109		
Total	11	0.0353217			

Figure 2. Photographic display of fresh tubers harvested from SAH micro-tuber seedlings transplanted in (A) September, 2020 in pot size 38.5×28.5cm; (B) September, 2020 in pot size 29.5×23.0cm; (C) October, 2020 in pot size 38.5×28.5cm; (D) October, 2020 in pot size 29.5×23.0cm.

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Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Norman PE and Kawa MS designed the experiment. Norman PE and Karim KY supervised the work. Norman PE performed the data analysis. Norman PE and Kawa MS drafted the manuscript. All the authors contributed to writing the article, read and approved its submission.

Abbreviation List

IITA, International Institute of Tropical Agriculture
MAT, Months After Transplanting
NRCRI, National Root Crops Research Institute
SAH, Semi-Autotrophic Hydroponics
SLARI, Sierra Leone Agricultural Research Institute
VFP, Virus Free Plants
YMT, Yam Minisett Technique

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