**NIGERIAN AGRICULTURAL JOURNAL**
ISSN: 0300-368X
Volume 53 Number 3, December 2022 Pg. 194-203
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng


# Screening $F_1$ Advanced Sweetpotato [*Ipomoea batatas* (L) LAM] Segregating Populations for Early Bulking, Dry Matter Content and Optimum Harvesting Time in Umudike, South-East Nigeria

**Nwankwo, I.I.M. and Nwankwo, P.O.**

National Root Crops Research Institute, Umudike, P.M.B 7006, Umuahia, Abia State, Nigeria
Corresponding Author's email: dr.patiencenwankwo@gmail.com

**Abstract**

Sweetpotato is an important carbohydrate root crop grown mainly for its storage roots for processing into various sweetpotato products due to its dry matter content. Twenty three (23) sweetpotato genotypes was conducted at the Western experimental field of NRCRI, Umudike in 2020 and 2021 to select potential early storage root bulking and maturing genotypes with high dry matter content for early cultivation genotypes. Objectives were to identify precise time for harvesting each genotype, select genotypes for extra-early, early, medium and late maturity for various end users. The experiment was laid out in a randomized complete block design with three replications. Each plot measured 4 x 3 m and comprised 4 ridges. Ten genotypes were used as samples per plot per genotype. The sweetpotato seed were cut 25 cm long, with at least 4 nodes, which were inserted two nodes on the crest of the ridges in a slanting position and spaced 1m between ridges and 0.3m apart along the row on the ridges. Ten (10) sweetpotato plants per plot were harvested at interval of 4 weeks after planting (WAP). Plant attributes studied were number of marketable roots at 8, 12, 16 and 20 weeks after planting and number of unmarketable roots. The yield data were subjected to analysis of variance and their means separated with standard error of difference at the probability level of 0.05. Four harvest dates for the sweetpotato genotypes were proposed; very early maturing, early maturing, intermediate and late maturing. The proposed dates were: 8, 12, 16 and 20 Weeks After Planting (WAP). Standard error of difference was used to assign genotypes to a harvest group/date. Results obtained indicated that Sweetpotato genotypes vary in their marketable root bulking and maturity dates, and harvesting at 8WAP would render the storage roots immature and unmarketable. Some genotypes required more than 16WAP to reach maturity. It is therefore, recommended that harvesting should be at 16 WAP. Assigning genotypes to a given harvest date is important for areas of short growing seasons as a result of short rainfall, areas of high disease infestation, areas with high market demand, for industrial uses depending on type of utility of the storage roots. Genotypes with dry matter of 28% are acceptable to most consumers.

***Keywords**: Sweetpotato, bulking, harvest date, dry matter and marketable roots*

## Introduction

Sweetpotato [*Ipomoea batatas* (L.) Lam] is cultivated in more than 100 countries of the world. (FAOSTAT, 2014) observed that sweetpotato is an important carbohydrate root crop grown as annual although could be perennial where the soil is very fertile. World sweetpotato production in 2020 was 89,487,835 tons under total area of 7,400,472 hectares. In the year 2022 under review, FAOSTAT (2022) reported that the continent of Asia was the largest producer of the crop which accounted for 62.6%. This was followed by the continent of Africa with 32.2%, while rest of the world produced 5.2%. In Africa, Nigeria was the largest sweetpotato producer (3,867,871 tons). In Nigeria, Sweetpotato is regarded as food security crop. Despite the crops nutritional and health benefit, it ranked 5$^{th}$ after rice, wheat, maize, and cassava (Thottappilly and Loebenstein, 2009; Woolfe, 1991).

Sweetpotato is seriously affected by water deficit especially during vine establishment and storage root bulking. This contributes to yield losses, yield gaps, poor quality planting material as a result of poor vine production, high infestation to pests and diseases, and poor absorption of soil nutrients (Gasura *et al*., 2010). Low *et al.* (2020) analysed factors contributing to sweetpotato yield gaps in sub-Sahara Africa and found that the most yield limiting factor was lack of rainfall distribution during the growing period resulting into yield gap at the average root yields of 8.0t/ha and 7.5t/ha for East and South Africa respectively and 3.0t/ha for West Africa (FAOSTAT, 2019). Although these figures are far below sweetpotato yield potential of 35t/ha in Research stations, the major factor is genetic yield potential and timely bulking to escape drought period and during drought.

The current research efforts are geared towards developing not only high yielders but also rapid storage root bulking and early types high starch content genotypes. The early maturing types produce yields of high tonnage. The number of storage roots as well as earliness of root bulking and maturity may depend on the genotype; assimilate supply, photoperiod, and temperature (Maini *et al*., 1977). The process of tuberous root formation and maturity may also depend on soil water supply, soil fertility and soil temperature (Ikpi *et al*., 1986). Storage root maturity is characterized by leaf area decline and a slow rate of storage root bulking/growth. This phase may not occur in the field when medium or late maturing genotypes are grown in a short season. Early season storage root initiation and bulking or growth is acceptable for production in areas where sweetpotatoes are harvested prior to physiological maturity. Environmental factors influence storage root bulking. For example, storage root bulking is best promoted by short photoperiods, high light intensity and cool climates, the meteorological factors influencing this process at a given location are basically air and soil temperatures, solar radiation, photoperiod, soil moisture, and crop water use (Githunguri, 2004). According to Nnodu *et al.* (2006), sensitivity to environmental conditions varies between genotypes. The most limiting environmental factors for sweetpotato production are heat and water stresses. Higher temperatures favor above ground biomass development and delay storage root initiation. Leaf senescence is also shortened by high temperatures, especially greater than 30°C as Maini *et al.* (1977) reported. Heat stress leads to a higher number of smaller storage roots per plant and reduced dry matter content.

Drought stress limits vine growth and reduces the number of storage roots in larger size categories. Breeding genotypes must be suited to the cropping systems and growing season of a particular region within their agro-ecological area of adaptation. Base on this, storage root bulking information of genotypes at an advanced stage of selection is of great interest for recommendation for testing toward final adoption. Farmers prefer sweetpotato varieties which have high yielding and early maturing capacity. The desired attributes of a good early sweetpotato types are early storage rooting, rapid storage root bulking and short maturity period coupled with high starch accumulation within a short period before the onset of dry season, good in-ground storability, and good cooking qualities (Nnodu *et al*., 2006). Early storage root bulking keeps pace with crop growth rate. Too early harvest of the sweetpotato crop often leads to reduction in storage root yield, while delayed harvest causes development of fibrous, weevil infested storage roots, reduction in starch content and deterioration of root quality (Ntawuruhunga *et al*., 1998). Dry matter content is a function of yield, starch content and carbohydrate value of the sweetpotato crop, the assessment of the storage root dry matter content under the different harvesting dates will add impetus as to the best time of harvest. Many factors influence the maturity period of sweetpotato however, these factors varied as per each genotype. The optimum stage of harvest depends on varieties and ecological factors. It was considered desirable to determine the influence of different stages of growth, storage root yield and yield related traits with a view to defining the optimum harvest time for some genotypes. This study aims at selection of potential early storage root bulking and maturing genotypes with high dry matter content for early cultivation genotypes and to have information on precise time for harvesting each genotype and to select genotypes for extra-early, early, medium and late maturing for various end users.

## Materials and Methods

***Study site and experiment details:*** The experiment was conducted in 2020 and 2021 cropping seasons at Umudike Umuahia Abia State, Nigeria. Umudike is located within latitude 05°17' and 05°27' North and longitude 05°29' and 07°32' East of the Greenwich Meridian at altitude 122m above sea level (NRCRI Metrology Unit, 2021). It lies in high rainfall forest area of over 2500 mm per annum, with mean photoperiod of 5 hours per day. The temperature is generally high, ranging from 27 to 34°C throughout the year. The average relative humidity is about 76%, with the lowest and highest values in January/December and July, respectively. The soil is typical Ultisoil of acid sandy loam soil. The trial was conducted at the Western experimental field of NRCRI, Umudike for assessing storage root bulking maturity of 23 sweetpotato genotypes. The site for the experiment was cleared and ridges constructed and spaced 1m apart. The experiment was laid out in a randomized complete block design with three replications. The 23 plots were replicated 3 times which gave a total of 69 plots, each plot measured 4 x 3m and comprised 4 ridges. Twenty-five sweetpotato genotypes were used for the experiment. Ten genotypes were used as samples per plot per genotype. The sweetpotato seed vines were cut 25 cm long, with at least 4 nodes. The seed vines were inserted two nodes° on the crest of the ridges in a slanting position and placed 1m between ridges and 0.3m apart along the row on the ridges. Thirty plants per plot, equivalent to 33,333 plants per hectare. The seed vines were treated with Decis EC 12 by dipping and spread under shade for one hour before planting, against soil inhabiting pests, especially termites and weevils which attack sweetpotato seed vines in the field. Weeding was manually done three times, using the West African hoe and hand pulling. Cross bars /ridge ties were constructed to control erosion and conserve soil moisture.

### *Data collection and analysis*

Ten sweetpotato plants from each plot were randomly selected and tagged for harvesting and data collection. Ten sweetpotato plants per plot were harvested at the interval of 4 weeks after planting (WAP). Plant attributes studied were number of marketable roots (that is storage roots with diameter of 4cm or weighed 100g) at 8, 12, 16 and 20 weeks after planting and number of unmarketable roots (that is storage roots with diameter less than 4cm or weighed less than 100g). The yield data were subjected to analysis of variance and their means separated with standard error of difference at the probability level of 0.05. Four harvest dates for the sweetpotato genotypes were proposed; very early maturing, early maturing, Intermediate and late maturing. The proposed dates were: 8, 12, 16 and 20 Weeks After Planting (WAP). From the Ten plants that were selected randomly from each plot, data on dry matter parameters were recorded during the period of the experiment such as dry matter weight of storage roots harvested at different WAP. The root samples were oven dried at 72°C temperature and calculated thus;

$$\text{Dry matter content of marketable root} = \frac{\text{weight of Oven dried marketable roots}}{\text{Fresh weight of marketable roots}}$$

***Statistical analysis***

All the collected data were analyzed following the analysis of variance (ANOVA) technique using a statistical computer software. Data collected in respect of each maturity group were first computed with analysis of variance (ANOVA) separately before a combined ANOVA across maturity groups and the two years growing seasons using PROC GLM model of SAS (SAS Institute, 2007) was computed to determine mean squares for each character. The degree of statistical difference was determined using probability levels P<0.01 and P< 0.05. Differences in character means were also measured using Standard error of difference means.

***Evaluation parameters***

***Data collected at harvest included marketable root size:*** Separate marketable roots i.e., those ≥ 4cm in diameter (>100g). The percentage of marketable roots and number of unmarketable roots were calculated: as those less than 4cm or less than 100g. At each harvest date 10 plants from each plot were harvested. Marketable root number was analyzed using analysis of variance (ANOVA). Means between harvest dates within test genotypes, and means between test genotypes at each harvest date are compared using standard error of difference.

***Data Interpretation:*** The Storage root bulking stage is a key determinant of the marketable component of total yield, characterized by a constant rate of increase in storage root size. Hence, performance of marketable storage root size across harvest date is of great importance in determining bulking maturity. To assign a test genotype to a given storage root bulking maturity grade, The genotype that did not perform statistically different for marketable storage root number across harvest date in the first harvest date can be regarded as early maturing. The genotypes that perform statistically better in the second harvest date though not significantly different to the third harvest date can be regarded as medium maturing. The genotypes that performed statistically better in the third harvest date can be regarded as late maturing. Genotypes that show no statistical difference in marketable storage root weight in two consecutive harvest dates may show a statistically significant increase in their marketable storage root yield. Since marketable storage root yield is a function of marketable storage root weight and number, a significant increase in marketable storage root yield can be attributed only to a greater number of marketable storage roots. This would be the case of sweetpotato genotypes that were able to produce additional storage roots during later stages of plant development or genotypes with more than one storage root setting cycle.

**Results and Discussion**

***Results***

During the cropping seasons of 2020 and 2021, there were adequate and evenly distribution of rains throughout the growing periods of May to October. In each of the growing year, there was a significant rainfall drop (August break) in August, 2020 and August 2021. The physico-chemical analysis of the soil of 0-15 and 15-30cm soil depth indicated that the soil at the experimental site was comparable in both depths in both years. The particle size analysis of the soil type was sandy loam with a high proportion of sand (74.3%) but less clay (5.7%), silt (20.4%). The chemical characteristics of the soil showed that the soil was slightly acidic (pH of 6.5) with adequate cation exchange capacity (12.90 cmol kg-1). The total Nitrogen (0.6%), organic carbon (9.8%), calcium (2.5 cmol kg-1) and magnesium (2.4 cmol kg-1) values were low. There was a high concentration of available phosphorus (7.4 mg kg-1). The results on the number of Marketable roots and dry matter content of the sweetpotato genotypes at 8, 12, 16 and 20 weeks after planting in 2020 cropping season are presented in Table 1.

The result indicated high significant difference (P<0.01) for the number of marketable roots that bulked at 8WAP (Table 1). Very few storage roots of most genotype reached marketable size at 8WAP. This low number of marketable root yield recorded indicated that the storage roots were still bulking and had not reached maturity. The standard error of 2.0 for marketable roots at 8WAP led to lack of statistical differences among the sweetpotato genotypes for this trait despite the wide range of yield values of 0 to 2.2 with mean number of marketable root of 0.3. The standard error of difference indicated that all the genotypes were still in the same group of immaturity and were still bulking. The mean number of unmarketable roots at 8WAP was high compared to other harvest dates representing 99.9% of total storage roots produced at date. These indicated that the earlier harvest interrupted the bulking rate of the roots reducing the storage root size and render the storage roots unmarketable in all the test sweetpotato genotypes. It is likely that most of the genotypes require more number of weeks to bulk to marketable size. Hence, it is not recommended to harvest any of the test genotypes at this date of 8WAP.

Table 1 shows that most of the sweetpotato genotypes had at 12 WAP produced significantly (P<0.01) greater number of storage roots of marketable size than others. The number of marketable root ranged from 0 to 16 with mean marketable root number of 7.4 which accounted for 90.2% of total number of storage roots produced by the test genotypes. The standard error difference of 5.0 account for the statistical difference of the genotypes at harvest date of 8WAP and 12WAP. Forty-eight percent (48.0%) of the genotypes showed good number of marketable root size when harvested at 12WAP. If harvesting was to be carried out, the sweetpotato genotypes that yielded more than the mean number of marketable roots of 7.4 and were grouped together by the standard error of difference would be selected. These genotypes should be harvested at 12WAP and regarded as early maturing based on the proposed four harvest dates. The genotypes included: PO3/11, PO3/93, PO3/14, PO3/119, PO3/38, NWA/OP/247, 87/OP/194, PO3/95, PO3/40, 87/OP/208 and NWA/OP/242. These sweetpotato genotypes should be of particular importance for areas of short growing seasons, where early harvesting is required, or areas for escape for disease and pests infestation or areas where the farmers require high produce turn-over as a result of high demand for storage roots for industrial raw material such as starch for flour.

At 16WAP the genotypes yielded significantly better even though a few marketable roots were harvested, they were not significantly different from those harvested at 12WAP. However, a significant greater number of marketable roots at 16WAP indicated that bulking was still in progress while at 12WAP for most of the genotypes and as such those genotypes could be regarded as intermediate/medium maturing genotypes. The marketable root size ranged from 0 to 13 with mean of 5.7 which accounted for 68.7% of total number of roots harvested while unmarketable root size number accounted for 31.3% of total number of storage roots harvested. This should be expected because some creeping sweetpotato genotypes continue to produce storage roots at the nodes that made contact with the soil. In contrast, no significant differences were observed for marketable number of roots across harvest dates of 12WAP and 16WAP. This indicated that these genotypes could as well be regarded as both early and medium maturing under Umudike conditions. The genotypes grouped under this date yielded more than the general mean number of marketable root of 5.7. The genotypes belonging to this group accounted for 65% and were: NWA/OP/231, NWA/OP/242, PO3/903, 87/OP/194, PO3/95, PO3/40, 87/OP/208, NWA/OP/247, 87/OP/287, PO3/38, PO3/01/14, PO3/03, PO3/11 and 87/OP/210. Their marketable root yield were above the mean yield of 5.7 number of marketable root yield. These genotypes could be harvested piece meal whenever the need arises in the household.

At 20WAP, few genotypes produced high significant (P< 0.01) mean number of marketable roots higher than the mean marketable root of 2.8 which accounted for 31.3% of the total storage root yield. This indicated that 3.9% of the genotypes could be late maturing. These genotypes were: 87/OP/145, PO3/903, PO3/95, PO3/119, PO3/11 and 87/OP/210. The standard error of difference placed them in late maturing group. The late maturing genotypes have an advantage over the early maturing ones as significantly higher marketable roots can be expected in a late harvest. This is important when farmers need to decide their harvest date according to the markets' demands and supply of sweetpotato roots. The medium/intermediate maturing sweetpotato genotypes such as NWA/OP/231 and PO3/01/14 had long senescence and died and could not survive up to 20WAP.

The result of the dry matter content in Table 1 in 2020 showed that dry matter content of the marketable bulked roots of the genotypes ranged from 0.0 to 11.0% with mean of 5.2%. The very low dry matter content of the marketable storage roots indicated that the storage roots at this stage were still bulking and very immature to be harvested at 8WAP. At 12 WAP, the dry matter content of the bulked marketable roots ranged from 10.0 to 28.0% with mean of 22.0%. The increased rate of dry matter content indicated that some of the genotypes that bulked could be harvested, although these genotypes are orange fleshed varieties that have negative correlation with dry matter content. The dry matter content of 28.0% is acceptable to consumers. The storage roots could be used for various value additions by food processors. The genotypes harvested at 16WAP had dry matter content that ranged from 0.0 to 28.0% with mean of 23.9%. At this harvest date, majority of the genotypes have reached their dry matter ceiling and could be harvested. The number of marketable roots at this stage could be acceptable for human and animal consumption. The genotypes harvested at 20WAP in Table 1 showed that dry matter content ranged from 0 to 28.0% with mean of 24.9%. These genotypes with their marketable roots have reached ceiling point for dry matter accumulation and could be harvested else they will be lignified.

The result of number of marketable roots and dry matter content of the sweetpotato genotypes at 8, 12, 16 and 20 weeks harvested in 2021 cropping season are presented in Table 2. Number of marketable roots in 2021 vary significantly (P<0.01) among the genotypes in all the proposed dates. The result in Table 2 showed very few mean number of marketable of root of 0.4 at 8 weeks after planting which accounted for 2.8%. The mean number of unmarketable root represented 97.2% of the total roots produced. This suggested that the storage roots of most of the genotypes were still bulking and were not yet mature. The number of marketable roots obtained ranged from 0 to 2. The high standard error of difference of 0.64 for marketable root at 8 weeks after planting indicated no statistical difference among the genotypes which showed that they are still in the same group of storage root immaturity and still bulking and therefore cannot be harvested at this stage. Harvesting the storage roots at this stage is tantamount to destroying and wasting the crop.

At 12 WAP, the mean number of marketable roots was 5.4 which represented 33.8% while the mean number of unmarketable roots was 11.4 or 66.4% of the total number of storage roots produced. This result indicated that major part of the storage roots was still bulking and immature. The marketable root number ranged from 0 to 14. The standard of error of difference for the number of marketable roots potential in the bulking accounted for statistical difference among the genotypes at 12 WAP. Some genotypes showed marketable root size when harvested at 12 WAP. However, 52% of the genotypes evaluated may be harvested at 12WAP as a result of producing 33.8% of marketable root yield.

At 16 WAP, mean marketable yield number was 11.3 which accounted for 75.2% of the total root yield while mean yield of unmarketable roots was 3.9 which represented 24.8%. The marketable root yield ranged from 0 to 18. At this stage, the genotypes yielded significantly better marketable roots potential. The statistical error of difference of 3.46 indicated significant difference means among the test genotypes. However significant differences were observed for number of marketable roots across harvest dates of 12WAP and 16WAP as shown by the standard error of difference. This group of genotypes could be assigned as medium maturing genotypes under Umudike agro-ecological condition. Forty-eight percent which yielded more than the grand mean fall under this group.

At 20 WAP yield of marketable roots varied significantly ($p<0.01$). It ranged from 2 to 10 with mean of 6.0 which accounted for 70.1% of total number of storage roots produced during this period. This showed that some genotypes were late maturing. The standard of error of difference of 2.52 grouped these genotypes under late maturing genotypes. Thirty-nine percent of the genotypes were under this group.

The dry matter content (DMC) of the genotypes at 8WAP in 2021 vary significantly ($P<0.01$) and ranged from 0.0 to 17.0% with mean of 17.3%. The low percentage DMC was as a result of immaturity of the bulking storage roots. The DMC was very low at this stage (Table 2). The result also indicated that at 12WAP, the DMC appreciated significantly ($P<0.01$) and ranged from 0.0 to 29.0% with mean of 23.0%. At this stage, the rate of bulking and dry matter accumulation had increased. Genotypes with dry matter accumulation up to 28.0% could be harvested at this stage.

The DMC of the test genotypes at 16WAP vary significantly ($P<0.01$) and ranged from 13.0 to 28.0% with mean of 27.1%. Most genotypes had increased percentage of dry matter at this stage and could be harvested for consumption. The high DMC is an indication of maturity and high starch content which conferred good taste to the storage root of the genotypes under test. In 20WAP, there was high significant variability in DMC of the genotypes under evaluation. The DMC ranged from 18.0 to 29.0% with mean of 27.0%. Most genotypes had their dry matter ceiling at this stage and could be harvested for consumption (Table, 2).

The Combined analysis of the Number of Marketable roots and Dry matter content of the sweetpotato genotypes harvested at 8, 12, 16 and 20 weeks after planting in 2020 and 2021 cropping season are presented in Table 3. The combined analysis for the two years indicated that number of marketable roots that bulked at 8WAP ranged from 0.0 to 2.5 with mean of 0.45. This accounted for 3.3% of the number of total roots produced by the test genotypes. However, number of unmarketable roots ranged from 7.0 to 28.5 which accounted for 96.7% which indicated that numbers of unmarketable roots (small roots) are still high and at their immature stage. This suggested that the storage roots were still bulking. Harvesting at this stage is not ideal and is tantamount to wasting the developing storage roots. Almost all the test genotypes were still bulking at this stage.

The number of marketable roots at 12WAP were highly significant ($p<0.01$) and ranged from 0.0 to 14.5 with mean of 6.4 roots which accounted for 52.0% of total roots produced by the test genotypes. This indicated that most genotypes produced roots that bulked at that date and that were marketable. The 48.0% of unmarketable roots indicated that there were roots in some genotypes that were still bulking. However, the standard error of 2.54 of marketable root size at 12WAP could be used to assign harvesting date to some genotypes at 12WAP. Genotypes with number of marketable roots above the Check variety TIS87/007 of 7.0 could be assigned to be harvested at 12WAP. These genotypes were: 87/OP/132 with (12.0 marketable roots (MR)), NWA/P/242 (10.5 MR), 87/OP/194 (14.5MR), PO3/95 (12.0MR), PO3/40 (10.0MR), 87/OP/208 (12.5MR), 87/OP/287 (14.0MR), PO3/38 (8.5MR), PO3/93 (9.0MR) and PO3/11 (7.5MR).

The combined analysis of the number of marketable roots at 16WAP showed that number of marketable roots of the genotypes that bulked at that date ranged from 0.0 to 13.0 with mean of 8.9. The high percentage of bulked roots that were of marketable root size at that date indicated that most genotypes bulked at that date. However, standard error for assigning harvest date (SE 3.04) indicated that although majority of the genotypes had high rate of root bulking at that date they do not differ much from those harvested at 12WAP. This also indicated that genotypes harvested at 12WAP could be harvested at 16WAP and could be assigned as intermediate genotypes. The high percentage of genotypes with bulked roots that were marketable showed that it was the best harvest date for most genotypes. The genotypes that could be assigned this harvest date were superior to the check variety TIS87/0087 with mean marketable bulked root of 9.0 marketable root (MR) include: 87/OP/145 (11.0MR), NWA/OP/231 (12.0MR), 87/OP/194 (13.0MR), PO3/95 (11.0MR), PO3/40 (13.0MR), NWA/OP/247 (12.0MR), 87/OP/287 (11.0MR), PO3/01/14 (12.0MR), PO3/93 (10.0MR), PO3/11 (13.0MR) and 87/OP/210 (12.0MR).

At 20WAP, the test genotypes produced bulked roots that were marketable that significantly ($p<0.01$) ranged from 1.0 to 9.5 with mean of 4.4 which represented 59.0%. Majority of the test genotypes had high number of bulked roots that were marketable. The number of unmarketable roots which accounted for 41.0% showed that some genotypes were creeping types and were producing small roots at the nodes that were not yet bulked as to attend marketable root size as at that date. The standard error of 2.87 that was used to assigned harvest date to the two harvesting dates indicated that some genotypes could be harvested at 20WAP and were regarded as late maturing. The late maturing genotypes were further selected based on their performance above the check variety TIS87/0087 which had mean of 6.5 marketable root size. The late maturing genotypes were: PO3/903 (8.0MR), 87/OP/194 (9.0MR), PO3/95 (8.0MR), PO3/119 (8.5MR) and 87/OP/210 (9.5).

The combined analysis indicated high significant ($P<0.01$) variation in DMC for all the proposed harvest dates. The DMC at 8WAP showed that the low percentage of DMC of the genotypes at 8WAP was as a result of storage root immaturity. The DMC ranged from 3.0 to 12.0% which showed that the DMC is very low due to low dry matter accumulation at that 8WAP harvest date. There was increase in DMC accumulation as at 12WAP. The dry matter accumulation ranged from 0.0 to 28.0% with mean of 22.3%. This showed that most genotypes could be harvested at the proposed harvest date of 12WAP. The genotypes harvested at 16WAP had DMC which ranged from 12.5% to 28.0% with mean of 24.8%. At this stage, most genotypes could be harvested for human consumption and for other value additions.

At 20WAP, the mean DMC was 25.6%. This ranged from 12.5 to 28.0%. This indicated that DMC accumulation of the marketable roots have reached it ceiling for most genotypes. Those genotypes with high dry matter content of 27 to 28.0% could be harvested for human consumption, as article for commerce or for other value additions.

**Discussion**

The mean high number of unmarketable roots at 8WAP compared to other harvest dates of total storage roots produced, indicated that the earlier harvest interrupted the bulking rate of the roots, thereby reducing the storage root size and render the storage roots unmarketable in all the test sweetpotato genotypes. This also showed that most of the genotypes require more number of weeks to bulk to marketable size. It is not recommended to harvest any of the test genotypes at this date. The high standard error of difference indicated no statistical difference among the genotypes which showed that they are still in the same group of storage root immaturity and still bulking and therefore cannot be harvested at this stage. Harvesting at this stage destroys the storage roots. Some genotypes showed marketable root size when harvested at 12 WAP. These sweetpotato genotypes should be of particular importance for areas of short growing seasons, where early harvesting is required, or areas for escape for disease and pests infestation or areas where the farmers require high produce turn-over as a result of high demand for storage roots for industrial raw material such as starch for flour.

At 16WAP the genotypes yielded significantly better. They were not significantly different from those harvested at 12WAP. However, a significant greater number of genotypes had bulked roots of marketable size at 16WAP. These genotypes could be regarded as intermediate/medium maturing genotypes However significant differences was observed for number of marketable roots across harvest dates of 12WAP and 16WAP as shown by the standard error of difference. This group of genotypes could be assigned as medium maturing genotypes under Umudike agro-ecological condition. Forty-eight percent which yielded more than the grand mean fall under this group. This indicated that these genotypes could as well be regarded as both early and medium maturing under Umudike conditions. According to Onyema (2008) sweetpotato is a tropical crop that is adapted to well drained sandy clay loam soil and has a short maturity period of 12 to 16 WAP with an average yield of 5.7 to 7.0t/ha. However, not all sweetpotato genotypes mature within this period. Most genotypes mature earlier and later than this period. Maturity in this sense is when the storage roots bulked up to marketable size which is 100g and above or 4cm in diameter and above.

At 20WAP, few genotypes produced high significant ($P< 0.01$) mean number of marketable roots yield. This indicated that most genotypes could be late maturing. The standard error of difference placed these genotypes in late maturing group. The late maturing genotypes have an advantage over the early maturing ones as significantly higher marketable roots can be expected in a late harvest. This is important when farmers need to decide their harvest date according to the markets' demands and supply of sweetpotato roots.

The duration and rate of storage root bulking in the sweetpotato plant determines the yield of the crop. The rate of storage root bulking describe the increase in storage root weight with time, while storage root bulking duration is the time between storage root initiation and persistence of the sweetpotato leaves. The decline in leaf area by senescence is as a result of the ceiling in storage root bulking. Although, some sweetpotato genotypee do not senesce its leaves throughout their growing period. Sweetpotato genotype which is still bulking exhibit profuse exudates of sap from crack of storage roots. This factor account for yield differences between genotypes. However, storage root bulking duration is of greater importance as it seems to determine the final yield of sweetpotato crop. Storage root bulking results from two basic processes which include storage root initiation and storage root growth. These two factors is also affected by timing, duration, location, environmental factors, and genetic make-up of the individual genotypes.

However, genotypes of medium or late bulking maturity can be recommended for an earlier harvest date provided that the genotype is among those with best marketable storage root weight and yield at the referred date. Therefore, a comparison test between genotypes at a given harvest date is of paramount importance for a final recommendation of the genotype's harvest date. This is of particular importance for areas of short growing seasons, where early harvesting is required. The varietal responses in storage root bulking, harvest dates and dry matter accumulation and ceiling depended on inherent genetic potential of the sweetpotato genotypes. Sweetpotato genotypes could be improved to mature extra early or medium maturing through breeding which could lead to shortening of longer leaf life, increase leaf area and leaf area ratio.

The dry matter content (DMC) at 8WAP showed low percentage of DMC. This was as a result of storage root immaturity. The DMC accumulation increased at 12WAP. The dry matter accumulation ranged from 0.0 to 28.0% with mean of 22.3%. This showed that most genotypes could be harvested at the proposed harvest date of 12WAP. The genotypes harvested at 16WAP had DMC which ranged from 12.5% to 28.0% with mean of 24.8%. At this stage, most genotypes could be harvested for human consumption and for other value additions.

At 20WAP, the mean DMC was 25.6%. This ranged from 12.5 to 28.0%. This indicated that DMC accumulation of the marketable roots have reached it ceiling for most genotypes. Those genotypes with high dry matter content of 27 to 28.0% could be harvested for human consumption, as article for commerce or for other value additions. Idowu and Kupoluyi (2008) reported that sweetpotato storage roots with dry matter content of 28 to 34% cold be used to process sweetpotato products such as: gari, bread, cake, biscuits, cookies, chips, flour, chin chin, doughnut, puff puff, meatpie, starch, juice, kunnu, microbiological agar ethanol and bio-fuel.

**Conclusion**

Sweetpotato genotypes vary remarkably in their marketable root bulking and maturity dates this indicates that earlier harvests render immature unmarketable size, resulting in the penalty of low yield. This is also evidenced by high percentage of small roots. Harvesting at that stage render storage roots immature, and unmarketable. It is evident that bulking was interrupted at 8WAP in all test clones and it was observed that some of the genotypes required more than 16WAP to reach maturity. Nevertheless, almost all clones showed good marketable tuber weight and number when harvested at 16 WAP. It is therefore recommended that harvesting should be at 16 WAP. Assigning genotypes to a given harvest date is of paramount importance for: areas of short growing seasons as a result of short rainfall, areas of high disease infestation, areas with high market demand, for industrial uses and depends on type of utility of the storage roots.

**References**

FAOSTAT (2014). Food and Agriculture Statistics Division. Rome: FAO.

FAOSTAT (2019). Available online at: http://www.fao.org/faostat/en/ (accessed December 4, 2019).

FAOSTAT (2022). Production of commodity in selected country, production share by region and production of top 10 producers. http://www.faostat3.fao.org

Gasura, E., Mashingaidze., A. and Mukasa., S. (2010). Genetic variability for tuber yield, quality, and virus disease complex traits in Uganda sweetpotato germplasm. *Afr. Crop Sci. J.*, 16,147–160.doi: 10.4314/acsj.v16i2.54355

Githunguri, C.M., Kanayake, I.J. and Waithaka, K. (2004). Effect of the growth environment and bulking rate on cyanogenic potential of cassava tuberous roots. Agricultural Research Institute, Nairobi (Kenya). Proceedings of the 8th KARI biennial Scientific Conference, held on 11th – 15th November. Pp. 151-157.

Idowu, A.O and Kupoluyi. O (2008). Processing and Utilization of Sweetpotato. . Proceeddings of the first National Sweetpotato Conference held during 16-18 September 2008 at the first bank hall, Faculty of Agriculture and Forestry University of Ibadan, Nigeria. (Ed.) Malachy Akoroda and Ijeoma Egeonu. September 2009. Pp15 -17.

Ikpi AE, Gebremeskel T, Hahn ND, Ezumah HC, Ekpere JA (1986). Cassava: a crop for household food security. IITA-UNICEF Collaborative Program Report, IITA, Ibadan, Nigeria, pp. 110-113.

Low, J. W., Ortiz, R., Vandamme, E., Andrade, M., Biawin, B., Grunerderd, W., 2020. Nutrient-Dense orange fleshed sweetpotato: Advabces in drought tolerant breeding and understanding of management practices for suitainable nexy-generation cropping systems in Sub-Sahara Africa. Front. Sustain. Food. Syst. 5:50 doi: 10.3389/fsufs.2020.00050

Maini SB, Indira P, Mandal RG (1977). Studies on maturity index in cassava. J. Root Crops 3(2):33-35.

Nnodu EC, Ezulike TO, Asumugha GN (2006). Cassava In: Idem NUA Showemino FA (Eds). Tuber and Fibre Crops of Nigeria: Principles of Production and Utilization, Ade Commercial Press, Zaria, pp. 22-35.

Ntawuruhunga P, Ojulong H, Dixon AGO (1998). Genetic variability among cassava genotypes and its growth performance over time. In: Root Crops and Poverty alleviation. Proceedings of the 6th Symposium of the ISTRC – African Branch. IITA, Ibadan, Nigeria, pp. 242-248.

Onyema Nwodo (2008). Sweetpotato production in Enugu State). Proceeddings of the first National Sweetpotato Conference held during 16-18 September 2008 at the first bank hall, Faculty of Agriculture and Forestry University of Ibadan, Nigeria. (Ed.) Malachy Akoroda and Ijeoma Egeonu. September 2009. Pp35 -37.

Thottappilly, G., Loebenstein, G., 2009. The Sweet potato. Springer, New York.

Woolf, J., 1992. Sweetpotato an untapped food resource. Cambridge University Press, Cambridge, UK.

**Table 1: Number of Marketable roots and dry matter content of the sweetpotato genotypes at 8, 12, 16 and 20 weeks of harvesting in 2020 cropping season**

| Varietal Name | 8 Weeks Marketable roots | Un-marketable roots | Total storage | % Dry matter content | 12 Weeks Marketable roots | Un-marketable roots | Total storage | % Dry matter content | 16 Weeks Marketable roots | Unmarketable roots | Total storage | % Dry matter content | 20 Weeks Marketable roots | Un-marketable roots | Total storage | %Dry matter content | Mean number of roots |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 87/OP/132 | 1 | 13 | 14 | 10.0 | 7 | 2 | 9 | 20.0 | 0 | 3 | 3 | 21.0 | 2 | 4 | 6 | 22.0 | 8.0 |
| PO3/016 | 0 | 7 | 7 | 5.0 | 7 | 0 | 7 | 24.0 | 0 | 0 | 0 | 0.0 | 2 | 4 | 6 | 28.0 | 5.0 |
| 87/OP/145 | 0 | 9 | 9 | 7.0 | 2 | 0 | 2 | 15.0 | 6 | 0 | 6 | 23.0 | 5 | 2 | 7 | 24.0 | 6.0 |
| NWA/OP/231 | 0 | 7 | 7 | 2.0 | 4 | 1 | 5 | 10.0 | 7 | 1 | 8 | 27.0 | 0 | 0 | 0 | 0.0 | 5.0 |
| NWA/OP/242 | 0 | 19 | 19 | 11.0 | 13 | 0 | 13 | 27.0 | 8 | 0 | 8 | 27.0 | 1 | 3 | 4 | 28.0 | 11.0 |
| PO3/903 | 0 | 14 | 14 | 3.0 | 6` | 2 | 6 | 17.0 | 6 | 0 | 6 | 21.0 | 7 | 1 | 8 | 23.0 | 9..0 |
| 87/OP/194 | 0 | 26 | 26 | 10.0 | 15 | 2 | 17 | 27.0 | 13 | 6 | 19 | 28.0 | 8 | 3 | 11 | 27.0 | 54.0 |
| PO3/95 | 1 | 31 | 32 | 11.0 | 16 | 2 | 18 | 28.0 | 11 | 4 | 15 | 28.0 | 8 | 10 | 18 | 26.0 | 21.0 |
| PO3/40 | 0 | 29 | 29 | 2.0 | 15 | 0 | 15 | 22.0 | 8 | 4 | 12 | 26.0 | 1 | 3 | 4 | 27.0 | 15.0 |
| 87/OP/208 | 0 | 8 | 8 | 4.0 | 16 | 0 | 16 | 28.0 | 9 | 3 | 11 | 27.0 | 3 | 5 | 8 | 28.0 | 10.8 |
| NWA/OP/247 | 0 | 36 | 36 | 6.0 | 8 | 1 | 9 | 18.0 | 12 | 8 | 20 | 28.0 | 1 | 8 | 9 | 29.0 | 19.0 |
| 87/OP/287 | 0 | 8 | 8 | 3.0 | 7 | 3 | 10 | 24.0 | 6 | 4 | 10 | 22.0 | 3 | 2 | 5 | 24.0 | 8.3 |
| PO3/38 | 1 | 14 | 15 | 4.0 | 9 | 1 | 10 | 26.0 | 9 | 3 | 12 | 27.0 | 3 | 4 | 7 | 28.0 | 12.0 |
| PO3/119 | 2 | 9 | 11 | 2.0 | 8 | 1 | 9 | 27.0 | 4 | 0 | 4 | 18.0 | 8 | 0 | 8 | 24.0 | 8.0 |
| NWA/OP/28 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0 | 0.0 | 0 | 6 | 6 | 19.0 | 1 | 0 | 1 | 22.0 | 2.0 |
| PO3/82 | 0 | 12 | 12 | 4.0 | 0 | 0 | 0 | 0.0 | 0 | 1 | 1 | 10.0 | 1 | 1 | 2 | 17.0 | 3.8 |
| MAX | 0 | 12 | 12 | 3.0 | 2 | 0 | 2 | 16.0 | 3 | 1 | 4 | 24.0 | 1 | 4 | 5 | 27.0 | 5.8 |
| PO3/01/14 | 2 | 7 | 9 | 6.0 | 8 | 3 | 11 | 27.0 | 12 | 3 | 15 | 28.0 | 0 | 0 | 0 | 27.0 | 9.3 |
| PO3/93 | 0 | 14 | 14 | 3.0 | 11 | 4 | 15 | 28.0 | 10 | 4 | 14 | 27.0 | 0 | 2 | 2 | 28.0 | 11.3 |
| NWA/OP/290 | 0 | 7 | 7 | 2.0 | 3 | 0 | 3 | 17.0 | 3 | 2 | 5 | 25.0 | 1 | 8 | 9 | 27.0 | 6.0 |
| PO3/11 | 0 | 19 | 19 | 3.0 | 9 | 2 | 11 | 28.0 | 8 | 4 | 12 | 27.0 | 3 | 5 | 8 | 28.0 | 13.0 |
| 87/OP/210 | 0 | 15 | 15 | 2.0 | 7 | 3 | 10 | 27.0 | 8 | 6 | 14 | 27.0 | 9 | 8 | 17 | 28.0 | 43.3 |
| TIS87/0087 | 0 | 5 | 5 | 6.0 | 4 | 2 | 6 | 22.0 | 0 | 3 | 3 | 29.0 | 2 | 1 | 3 | 31.0 | 4.3 |
| Mean | 0.3 | 14.0 | 15.1 | 5.2 | 7.4 | 1.2 | 8.2 | 22.0 | 5.7 | 2.7 | 8.3 | 23.9 | 2.8 | 3.1 | 5.9 | 24.9 | 11.6 |
| Range | 0-2 | 0-36 | 0-36 | 0.0-11. | 0-16 | 0-4 | 0-18 | 10-28 | 0-13 | 0-8 | 0-20 | 0-28 | 0-9 | 0-10 | 0-18 | 0-28 | 2.0-54. |
| SE | 2.2 | 3.8 | = | = | 5.0 | 2.0 | = | = | 1.0 | 3.0 | = | = | 3.2 | 2.1 | = | = | = |
| % | 0.02 | 99.9 | = | = | 90.2 | 9.8 | = | = | 68.7 | 31.3 | = | = | 47.5 | 52.5 | = | = | = |

**Table 2: Number of Marketable roots and dry matter content of the sweetpotato genotypes at 8, 12, 16 and 20 weeks harvested in 2021 cropping season**

| | 8 Weeks | | | | 12 Weeks | | | | 16 Weeks | | | | 20 Weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Varietal Name | Marketable roots | Unmarket able roots | Total storage | %Dry matter content | Marketable roots | Unmarket able roots | Total storage | %Dry matter content | Marketable roots | Unmarket able roots | Total storage | %Dry matter content | Marketable roots | Unmarket able roots | Total storage | %Dry matter content | Mean number of roots across harvest dates |
| 87/OP/132 | 1 | 8 | 9 | 12.0 | 5 | 12 | 17 | 21.0 | 10 | 6 | 16 | 25.0 | 7 | 4 | 11 | 23.0 | 13.0 |
| PO3/016 | 0 | 4 | 4 | 5.0 | 5 | 13 | 18 | 25.0 | 13 | 0 | 13 | 27.0 | 6 | 4 | 10 | 28.0 | 11.0 |
| 87/OP/145 | 2 | 7 | 9 | 8.0 | 2 | 0 | 2 | 10.0 | 16 | 0 | 16 | 26.0 | 4 | 2 | 6 | 25.0 | 8.0 |
| NWA/OP/231 | 0 | 10 | 10 | 12.0 | 2 | 12 | 14 | 18.0 | 17 | 1 | 18 | 27.0 | 1 | 1 | 2 | 18.0 | 11.0 |
| NWA/OP/242 | 1 | 11 | 12 | 12.0 | 8 | 15 | 23 | 27.0 | 8 | 0 | 8 | 28.0 | 4 | 1 | 5 | 28.0 | 12.0 |
| PO3/93 | 0 | 16 | 16 | 5.0 | 7` | 18 | 25 | 27.0 | 6 | 0 | 6 | 23.0 | 9 | 2 | 11 | 26.0 | 15.0 |
| 87/OP/194 | 2 | 22 | 24 | 12.0 | 14 | 14 | 28 | 27.0 | 13 | 6 | 19 | 28.0 | 10 | 3 | 13 | 28.0 | 21.0 |
| PO3/95 | 1 | 26 | 27 | 13.0 | 8 | 17 | 25 | 28.0 | 11 | 4 | 15 | 28.0 | 8 | 5 | 13 | 28.0 | 20.0 |
| PO3/40 | 0 | 23 | 23 | 6.0 | 5 | 10 | 15 | 24.0 | 18 | 4 | 22 | 26.0 | 4 | 1 | 5 | 22.0 | 16.0 |
| 87/OP/208 | 0 | 11 | 11 | 14.0 | 9 | 11 | 20 | 28.0 | 9 | 3 | 11 | 27.0 | 5 | 5 | 10 | 28.0 | 13.0 |
| NWA/OP/247 | 0 | 28 | 28 | 8.0 | 8 | 13 | 21 | 28.0 | 12 | 8 | 20 | 28.0 | 6 | 4 | 10 | 29.0 | 20.0 |
| 87/OP/287 | 0 | 12 | 12 | 4.0 | 7 | 23 | 20 | 28.0 | 16 | 4 | 20 | 27.0 | 4 | 2 | 6 | 25.0 | 15.0 |
| PO3/38 | 0 | 16 | 16 | 5.0 | 8 | 11 | 19 | 27.0 | 9 | 3 | 12 | 27.0 | 7 | 4 | 11 | 28.0 | 15.0 |
| PO3/119 | 1 | 13 | 14 | 17.0 | 8 | 14 | 22 | 27.0 | 14 | 0 | 14 | 28.0 | 9 | 1 | 10 | 23.0 | 15.0 |
| NWA/OP/28 | 0 | 5 | 5 | 1.0 | 0 | 1 | 1 | 17.0 | 0 | 13 | 13 | 18.0 | 5 | 2 | 7 | 26.0 | 7.0 |
| PO3/82 | 0 | 2 | 2 | 3.0 | 0 | 0 | 0 | 0.0 | 0 | 10 | 10 | 13.0 | 8 | 3 | 11 | 19.0 | 6.0 |
| MAX | 0 | 22 | 22 | 5.0 | 0 | 8 | 10 | 26.0 | 7 | 1 | 8 | 26.0 | 7 | 2 | 9 | 27.0 | 12.0 |
| PO3/01/14 | 1 | 12 | 13 | 6.0 | 5 | 13 | 18 | 27.0 | 12 | 3 | 15 | 28.0 | 2 | 0 | 2 | 27.0 | 12.0 |
| PO3/93 | 0 | 12 | 12 | 6.0 | 7 | 14 | 21 | 28.0 | 10 | 4 | 14 | 27.0 | 6 | 1 | 7 | 28.0 | 14.0 |
| NWA/OP/290 | 0 | 10 | 10 | 4.0 | 0 | 6 | 6 | 22.0 | 12 | 6 | 18 | 26.0 | 8 | 3 | 11 | 27.0 | 11.0 |
| PO3/11 | 0 | 21 | 21 | 6.0 | 6 | 12 | 18 | 28.0 | 18 | 4 | 22 | 27.0 | 4 | 5 | 9 | 28.0 | 18.0 |
| 87/OP/210 | 0 | 18 | 18 | 4.0 | 6 | 13 | 19 | 27.0 | 16 | 6 | 22 | 27.0 | 10 | 3 | 13 | 27.0 | 18.0 |
| TIS87/0087 | 0 | 10 | 10 | 5.0 | 4 | 12 | 16 | 29.0 | 18 | 3 | 21 | 29.0 | 6 | 3 | 9 | 32.0 | 14.0 |
| Mean | 0.4 | 14.0 | 14.0 | 7.3 | 5.0 | 11.0 | 16.0 | 23.0 | 12.0 | 4.0 | 15.0 | 27.1 | 6.0 | 3.0 | 9.0 | 27.0 | 13.0 |
| Range | 0-2 | 2- 28 | 2-28 | 0-17. | 0-14 | 1-23 | 0-28 | 0-29 | 0-18 | 0-8 | 1-22 | 13-28 | 2-10 | 0-5 | 2-13 | 18-29 | 6.0-21.0 |
| SE | 0.64 | 3.82 | = | = | 2.32 | 3.44 | = | = | 3.46 | 2.02 | = | = | 2.52 | 1.61 | = | = | = |
| % | 2.8 | 97.2 | = | = | 33.8 | 66.2 | = | = | 75.2 | 24.8 | = | = | 70.1 | 29.9 | = | = | = |
| Sig. level | P<0.01 | P<0.01 | | | P<0.01 | P<0.01 | | | P<0.01 | P<0.01 | | | P<0.01 | P<0.01 | | | |

**Table 3: Combined analysis of the Number of Marketable roots and Dry matter content of the sweetpotato genotypes harvested at 8, 12, 16 and 20 weeks after planting in 2020 and 2021 cropping season**

| Varietal Name | 8 Weeks | | | | 12 Weeks | | | | 16 Weeks | | | | 20 Weeks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marketable roots | Unmarketable roots | Total storage | % Dry matter content | Marketable roots | Unmarketable roots | Total storage | % Dry matter content | Marketable roots | Unmarketable roots | Total storage | % Dry matter content | Marketable roots | Unmarketable roots | Total storage | % Dry matter content | Mean number of roots across harvest dates |
| 87/OP/132 | 1.0 | 10.5 | 11.5 | 10.5 | 12.0 | 7.0 | 19.0 | 20.5 | 5.0 | 4.5 | 9.5 | 23.0 | 4.5 | 4.0 | 8.5 | 22.5 | 10.5 |
| PO3/016 | 0.0 | 8.0 | 8.0 | 5.0 | 0.0 | 5.5 | 5.5 | 24.5 | 6.5 | 0.0 | 6.5 | 13.5 | 4.0 | 4.0 | 8.0 | 28.0 | 8.0 |
| 87/OP/145 | 1.0 | 8.5 | 9.0 | 7.5 | 2.0 | 6.5 | 8.5 | 12.5 | 11.0 | 0.0 | 11.0 | 24.5 | 4.5 | 2.0 | 6.5 | 24.5 | 7.0 |
| NWA/OP/231 | 0.0 | 15.0 | 8.5 | 7.0 | 2.0 | 5.5 | 7.5 | 14.0 | 12.0 | 1.0 | 13.0 | 27.0 | 0.5 | 0.5 | 1.0 | 12.5 | 8.0 |
| NWA/OP/242 | 0.5 | 15.0 | 15.5 | 11.5 | 10.5 | 7.5 | 18.0 | 27.0 | 8.0 | 0.0 | 8.0 | 27.5 | 2.5 | 2.0 | 4.5 | 23.0 | 11.5 |
| PO3/93 | 0.0 | 24.0 | 15.0 | 4.0 | 6.5 | 10.0 | 16.5 | 22.0 | 6.0 | 0.0 | 6.0 | 22.0 | 8.0 | 1.5 | 9.5 | 25.5 | 12.0 |
| 87/OP/194 | 2.0 | 28.5 | 26.0 | 11.5 | 14.5 | 8.0 | 22.5 | 27.0 | 13.0 | 6.0 | 19.0 | 28.0 | 9.0 | 3.0 | 12.0 | 26.5 | 37.5 |
| PO3/95 | 2.0 | 26.0 | 30.5 | 12.0 | 12.0 | 9.5 | 21.5 | 28.0 | 11.0 | 4.0 | 15.0 | 28.0 | 8.0 | 7.5 | 15.5 | 27.0 | 20.5 |
| PO3/40 | 0.0 | 9.5 | 26.0 | 4.0 | 10.0 | 5.0 | 15,0 | 23.0 | 13.0 | 4.0 | 17.0 | 26.0 | 2.5 | 2.0 | 4.5 | 27.5 | 15.5 |
| 87/OP/208 | 0.0 | 32.0 | 9.5 | 7.0 | 12.5 | 5.5 | 18.0 | 28.0 | 9.0 | 3.0 | 12.0 | 27.0 | 4.0 | 5.0 | 9.0 | 25.0 | 11.9 |
| NWA/OP/247 | 0.0 | 10.0 | 32.0 | 7.0 | 4.0 | 7.0 | 11.0 | 23.0 | 12.0 | 8.0 | 20.0 | 28.0 | 3.5 | 6.0 | 9.5 | 28.5 | 19.5 |
| 87/OP/287 | 0.0 | 15.0 | 10.0 | 3.5 | 14.0 | 13.0 | 27.0 | 26.0 | 11.0 | 4.0 | 15.0 | 27.0 | 3.5 | 2.0 | 5.5 | 26.5 | 11.7 |
| PO3/38 | 1.5 | 11.0 | 16.5 | 4.5 | 8.5 | 6.0 | 14.5 | 26.5 | 9.0 | 3.0 | 12.0 | 27.0 | 5.0 | 4.0 | 9.0 | 26.5 | 13.5 |
| PO3/119 | 1.5 | 2.5 | 12.5 | 9.5 | 4.5 | 7.5 | 12.0 | 27.0 | 9.0 | 0.0 | 9.0 | 23.0 | 8.5 | 0.5 | 9.0 | 26.0 | 11.5 |
| NWA/OP/28 | 0.0 | 7.0 | 2.5 | 0.5 | 0.0 | 0.5 | 0.5 | 8.5 | 0.0 | 6.5 | 6.5 | 18.5 | 3.0 | 1.0 | 4.0 | 22.5 | 4.5 |
| PO3/82 | 0.0 | 17.0 | 7.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.5 | 5.5 | 12.5 | 3.5 | 2.0 | 6.5 | 21.5 | 4.9 |
| MAX | 0.0 | 9.5 | 17.0 | 4.0 | 1.0 | 4.0 | 5.0 | 21.0 | 5.0 | 1.0 | 6.0 | 25.0 | 4.0 | 3.0 | 7.0 | 27.0 | 9.4 |
| PO3/01/14 | 1.5 | 13.0 | 11.0 | 6.0 | 6.5 | 8.0 | 14.5 | 27.0 | 12.0 | 3.0 | 15.0 | 28.0 | 1.0 | 0.0 | 1.0 | 27.0 | 10.7 |
| PO3/93 | 0.0 | 8.5 | 13.0 | 4.5 | 9.0 | 9.0 | 18.0 | 28.0 | 10.0 | 4.0 | 14.0 | 27.0 | 3.0 | 1.5 | 4.5 | 28.0 | 12.7 |
| NWA/OP/290 | 0.0 | 18.5 | 8.5 | 3.0 | 1.5 | 3.0 | 4.5 | 19.5 | 7.5 | 4.0 | 11.5 | 25.5 | 3.5 | 5.5 | 10.0 | 27.0 | 8.5 |
| PO3/11 | 0.0 | 18.5 | 18.5 | 4.5 | 7.5 | 7.0 | 14.5 | 28.0 | 13.0 | 4.0 | 17.0 | 27.0 | 3.5 | 5.0 | 8.5 | 28.0 | 15.5 |
| 87/OP/210 | 0.0 | 16.5 | 16.5 | 3.0 | 3.5 | 8.0 | 14,5 | 27.0 | 12.0 | 6.0 | 18.0 | 27.0 | 9.5 | 5.5 | 15.0 | 27.5 | 30.7 |
| TIS87/0087 | 0.0 | 7.5 | 7.5 | 5.5 | 7.0 | 7.0 | 11.0 | 25.5 | 9.0 | 12.0 | 21.0 | 29.0 | 4.0 | 2.0 | 6.0 | 31.5 | 9.2 |
| Mean | 0.45 | 13.4 | 13.6 | 6.2 | 6.4 | 6.5 | 12.9 | 22.3 | 8.9 | 3.35 | 12.21 | 24.8 | 6.4 | 3.05 | 7.45 | 25.6 | 12.3 |
| Range | 0-2 | 7-28.5 | 7-32 | 3- 12 | 0-14.5 | 0-14.5 | 0-0.0 | 0-28 | 0-13 | 0-12 | 6.5-21 | 12.5-28 | 1-9.5 | 0-7.5 | 1-15.0 | 12.5-28 | 4.5-37.5 |
| SE | 0.68 | 3.74 | = | = | 2.54 | 2.52 | = | = | 3.04 | 1.87 | = | = | 2.87 | 1.77 | = | = | = |
| % | 3.3 | 96.7 | = | = | 49.0 | 51.0 | = | = | 72.8 | 27.2 | = | = | 59.0 | 41.0 | = | = | = |
| Sig level | P<.01 | P<.01 | = | = | P<0.01 | P<.01 | = | = | P<.01 | P<.01 | = | = | P<.01 | P<.01 | = | = | = |