# EVALUATION OF NEW FILBERT OBJECTIVE YIELD PROCEDURES

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## I. Introduction

Filbert objective yield estimates were made in Oregon and Washington from 1955 to 1964 but were dropped because they were inaccurate. The survey was resumed in 1968 and 1969. The direct expansion estimates of biological production from the objective counts for these two years were considerably lower than the filbert production which actually reached processors.

In 1969, Wigton 1/ did a study to determine better sampling methods and survey procedures for collecting objective yield information. He found that when clusters of nuts are counted on a sample limb (without stripping), the resulting count is about 15 percent below the number obtained by first stripping all nuts from the limb and then counting. There is also a high positive correlation between the relative size of a tree and its productivity. He, therefore, developed a double sampling scheme for selecting trees so that tree size could be used in the estimating process.

## II. Objectives

The objectives of this study were (1) determine on an operational level if the recommended procedures would produce a significantly better estimate of filbert production and (2) determine the size and weight change in the filbert nut from the time of the August 1 survey until harvest.

## III. Summary

1. The new double sampling procedure produced a much higher estimate than the old sample procedure but still less than the actual production from sheller's information.

2. There was a very definite decrease in nut size from green size to air dry size (10 percent moisture) to oven dry size. The shrinkage increased as green nut size increased. There was a high correlation between green size and the amount of shrinkage.

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1/ "A Study of New Objective Yield Procedures for Filberts" by William H. Wigton, Research & Development Branch, Standards & Research Division, Statistical Reporting Service.

3. New weights per nut were derived using data from the last three years. These weights were higher than the previous set used in the forecast model. The new weights should increase the estimate approximately 8 to 10 percent. The new weights probably allowed for less shrinkage.

4. The number of size groups used on the survey was reduced from 16 to 8. They follow new size standards as set by USDA.

5. Final dry weight per nut can be estimated from green weight at the time of the August 1 survey. The two sets of data had a r value of .99226. The dry weight can be estimated using the following formula.

$$\hat{Y} = .1765 + .72727 X$$

Where $\hat{Y}$ = estimated final dry weight per nut in grams

$X$ = August 1 green weight per nut

## IV. 1970 Production Forecast Survey

### A. Sample Selection

In order to incorporate the recommendations made by Wigton into the objective yield survey, one-third of the sample blocks used in 1969 were replaced with new blocks.

In the spring of 1970, 75 new sample blocks were drawn. In each of these blocks, a systematic sample of 12 trees was measured and ranked according to size (cross section area of primary limbs). A systematic sample of three trees from this array was then selected for making cluster counts. On each tree selected for counting, all primary limbs were identified and one primary limb was selected with equal probability. Two terminal units (limbs), to be stripped, were then selected with equal probabilities from this primary. Only 72 new blocks were laid out due to producer refusal or disappearance of blocks due to new housing developments.

### B. Field Procedures

In August 1970, these 72 new blocks were again visited. The three count trees previously selected were located and the nuts stripped from the two selected terminals on each tree. Two-man teams were used for stripping the nuts. This way a check could be made by the second person to see if any nut clusters had been missed. The nuts were then bagged and identified by terminal limb and sent to the state laboratory for further analysis.

A quality control check was made on several of the blocks soon after the original stripping was done. The preselected terminals were located in the count trees and checked for any nut clusters that had been missed previously.

C. Laboratory Procedures

The procedures followed in the laboratory for the green filberts sampled the first part of August 1970 are shown in flow chart form in Figure 1. The numbers on the flow chart in Figure 1 refer to the subsection headings below.

1. Samples sent to laboratory - The filberts were in clusters of one to eight or more nuts. These clusters were broken apart into single nuts which were then counted and weighed.

2. Subsample - A subsample of nuts was drawn from each sample if the number of nuts in the sample was more than could be handled in the laboratory. The upper limit was set at 100 nuts but had to be lowered to 50 nuts. For samples above this limit, nuts were placed in a line and a random sample selected. The nuts were then divided into two equal parts. Each portion of the subsample was husked and sized using a sizing plate. One portion was used for the forecast of production in 1970. The other half was used for research on nut shrinkage between August and harvest.

3. Summary and estimating program - The portion used for this part of the analysis was divided into size groups and cracked to determine how many defective nuts were in each size group. The defective and good nuts were weighed separately to determine a total weight for each.

4. Research on nut weights - The half of the nuts used for this part of the analysis was divided into two groups. One group was air dried only and the other group was to be air dried and oven dried. One-third of the nuts were air dried and oven dried while two-thirds were air dried only. The following description follows through each operation.

5. Air dry only - These nuts were counted and weighed by size groups and then set to air dry in cloth bags. At approximately the 10 percent moisture level, the nuts were again sized, weighed, counted by size group and discarded.

6. Air dry and oven dry - This group was again divided into two groups: One-third for keeping tract of size changes during drying and two-thirds for drying only.

7. Drying only sample - This group of nuts was sized and weighed by size group at three different stages--green, air dry, and oven dry. They were then discarded.

8. Size change sample - These nuts were sized, numbered (for size group) and weighed when green. They were again sized and weighed at the air dry and oven dry stages. The size and weight at these stages were recorded in order to relate oven dry size to green size. They were then discarded.

## D. Distribution of Nuts

There were 7,015 round type nuts and 1,154 elongate type nuts processed in this part. The modal size groups were size group 11 for the round type nut and size group 8 for the elongate type nut. These two size groups contained 23.635 percent and 16.898 percent of total nuts, respectively. Graphs 1 and 2 show the distribution of nuts when green in a breakdown of all nuts into good nuts and defective nuts. Table 1 shows the actual percentage in each size group by nut type.

The percent of defective nuts was 18.6 percent for round type nuts and 19.8 percent for the elongate type of nut. This gave an overall 18.8 percent defective nuts as shown in Table 1.

## E. 1970 Production Estimate

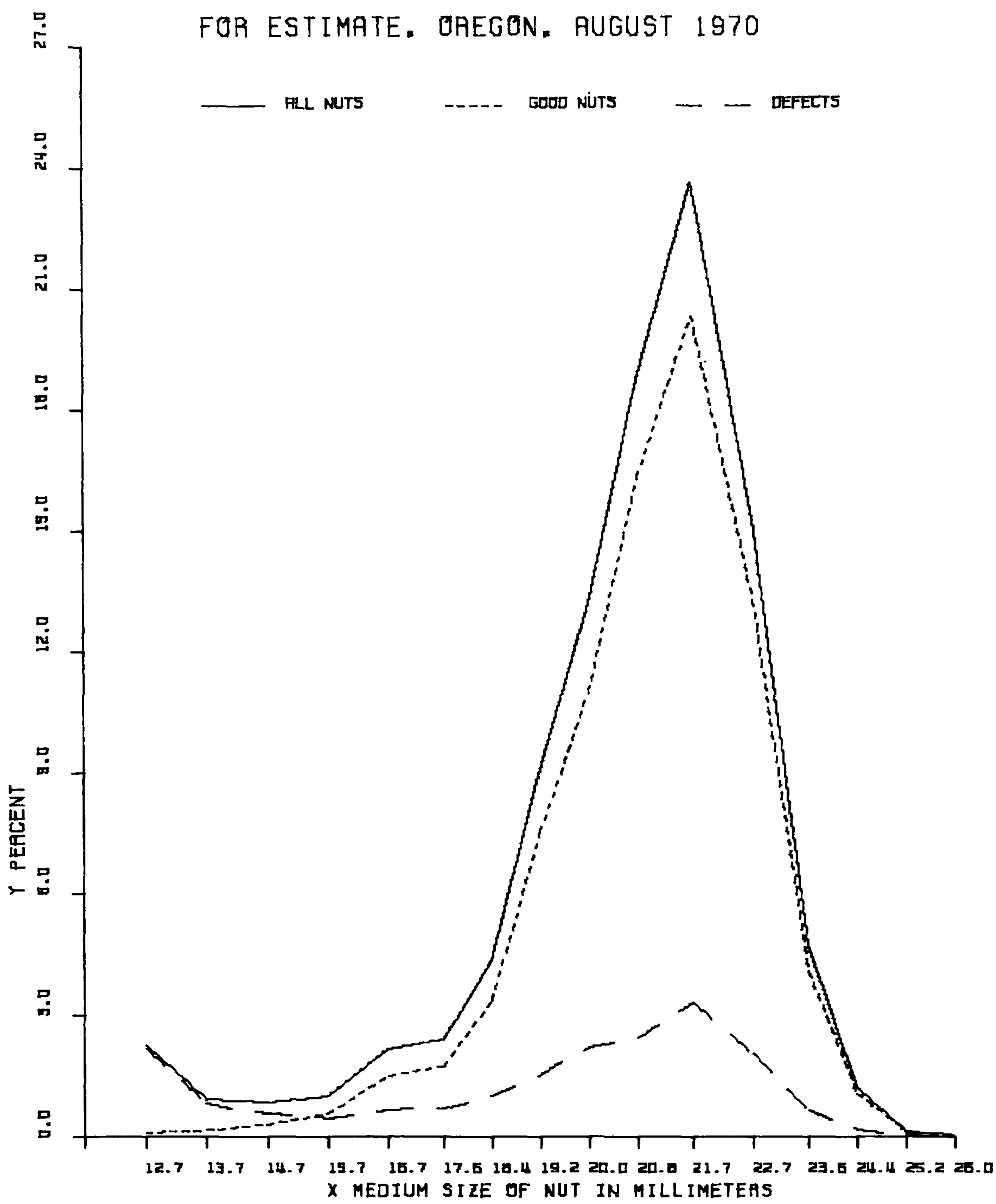
The estimated production for 1970 was computed using three different estimators. These included a direct expansion estimate, a two-stage regression estimate and a three-stage regression estimate. The general equation for all three estimators is:

$$\hat{Y}_{g(h)} = \frac{M_h}{m} \sum_{i=1} \hat{Y}_{hi}$$

Where $M_h$ = total trees in stratum
$m$ = 3 = number of trees sampled per block
$\hat{Y}_{hi}$ = block expanded total nuts for three trees
$g$ = estimator number - 1, 2 or 3

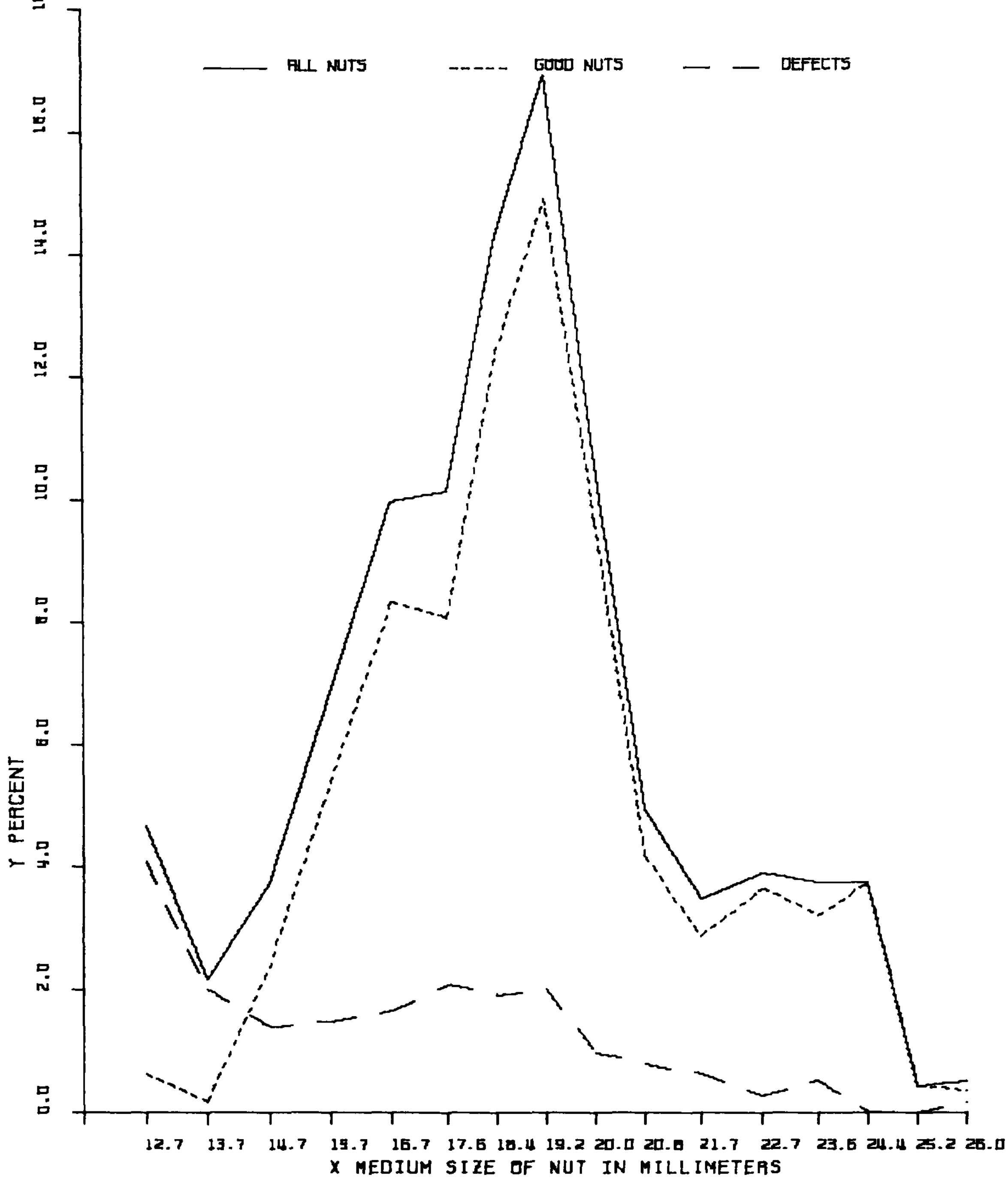
This last value changes from one estimator to the next.

GRAPH 1. DISTRIBUTION OF ROUND NUTS USED FOR ESTIMATE, OREGON, AUGUST 1970



GRAPH 2. DISTRIBUTION OF ELONGATE NUTS

USED FOR ESTIMATE, OREGON, AUGUST 1970



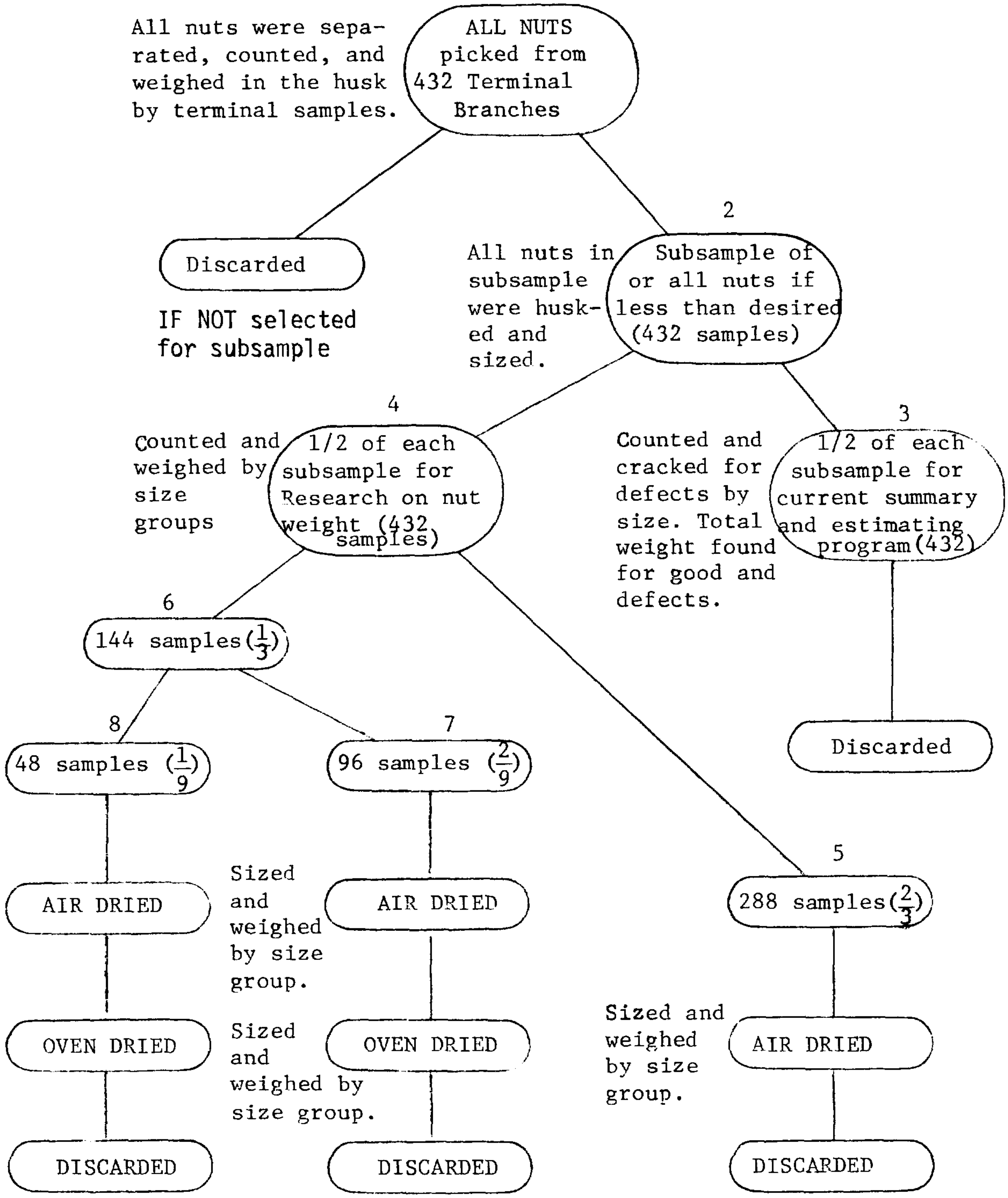



Figure 1.- Flow chart of laboratory procedures for green filberts sampled the first part of August 1970

Table 1.- Percent of nuts in each size group by nut type when green for all nuts, good nuts, and defective nuts, Oregon, August 1970

| Size | Round type | | | Elongate type | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| m.m. | All | Good | Defects | All | Good | Defects | All | Good | Defects |
| 12.7 | 2.25 | .08 | 2.17 | 4.68 | .61 | 4.07 | 2.60 | .16 | 2.44 |
| 13.7 | .93 | .14 | .79 | 2.16 | .17 | 1.99 | 1.10 | .15 | .95 |
| 14.7 | .84 | .30 | .54 | 3.73 | 2.34 | 1.39 | 1.25 | .59 | .66 |
| 15.7 | 1.01 | .55 | .46 | 6.85 | 5.37 | 1.47 | 1.84 | 1.24 | .60 |
| 16.7 | 2.15 | 1.50 | .65 | 9.96 | 8.32 | 1.64 | 3.26 | 2.46 | .80 |
| 17.6 | 2.41 | 1.74 | .67 | 10.14 | 8.06 | 2.08 | 3.50 | 2.63 | .87 |
| 18.4 | 4.36 | 3.36 | 1.00 | 14.30 | 12.39 | 1.91 | 5.77 | 4.64 | 1.13 |
| 19.2 | 9.08 | 7.54 | 1.54 | 16.90 | 14.91 | 1.99 | 10.18 | 8.58 | 1.60 |
| 20.0 | 13.20 | 11.00 | 2.20 | 10.57 | 9.62 | .95 | 12.83 | 10.81 | 2.02 |
| 20.8 | 18.78 | 16.34 | 2.44 | 4.94 | 4.16 | .78 | 16.82 | 14.62 | 2.20 |
| 21.7 | 23.64 | 20.33 | 3.31 | 3.47 | 2.86 | .61 | 20.79 | 17.86 | 2.93 |
| 22.7 | 15.30 | 13.27 | 2.03 | 3.90 | 3.64 | .26 | 13.68 | 11.91 | 1.77 |
| 23.6 | 4.70 | 4.06 | .64 | 3.73 | 3.21 | .52 | 4.56 | 3.94 | .62 |
| 24.4 | 1.21 | 1.05 | .16 | 3.73 | 3.73 | .00 | 1.57 | 1.43 | .14 |
| 25.2 | .11 | .08 | .03 | .43 | .43 | .00 | .16 | .14 | .02 |
| 26.0 | .03 | .03 | .00 | .52 | .35 | .17 | .09 | .07 | .03 |
| Total | 100.00 | 81.37 | 18.63 | 100.00 | 80.17 | 19.83 | 100.00 | 81.22 | 18.78 |

The variance of this estimator is

$$\sigma^2_{\hat{y}g(h)} = \frac{M_h^2}{9} \quad \frac{\Sigma \hat{Y}_{hi}^2 - (\Sigma \hat{Y}_{hi})^2 / n_h}{n_h (n_h - 1)}$$

1. The direct expansion estimate is:

$$\hat{Y}_{1(hi)} = \sum_j \sum_k \hat{Y}_{1(hijkL)}$$

Where $\hat{Y}_{1(hijkL)}$ is the expanded estimated weight of good nuts per tree by terminals.

$$\hat{Y}_{1(hijkL)} = n_{ij} \; t_{ijk} \frac{NTOT(L)}{\sum_M NSBTL(M)} \sum_{M=1}^{16} W(IT,M) \; (NSBTL(M) - NDL(M))$$

Where h = 1, 2, 3 age groups (stratum)
- i = 1, 2, . . . , $n_h$ sample blocks per age group
- j = 1, 2, 3 count trees per sample block
- k = selected primary
- L = 1, 2 sample units on selected primary
- M = 1, 2, . . . , 16 nut size groups
- $n_{ij}$ = number of primaries (p.s.u.'s) within the jth tree
- $t_{ijk}$ = is the total number of secondary sample units (terminals) on the selected primary
- NTOT(L) is the laboratory count of all nuts from the Lth secondary sample unit
- NSBTL(M) is the total number of nuts, both good and bad, in the Mth size group - from a subsample of NTOT(L)
- IT = 1, Barcelona type (round)
  = 2, Duchilly type (elongate)
- W(IT, M) is the historic average weight of good nuts of the ITth type and Mth size
- NDL(M) is the number of defective nuts in the Mth size group, from the same subsample as NSBTL(M)

2. The two-stage regression estimate is:

$$\hat{Y}_{2(hi)} = \sum_j \hat{Y}_{2(hij)}$$

Where $\hat{Y}_{2(hij)}$ is the two-stage regression estimate of weight of good nuts per tree adjusted for primary CSA within trees.

$$\hat{Y}_{2(hij)} = \hat{Y}_{1(hij)} - b_1(X_{hijk} - \bar{X}_{hij})$$

Where $X_{hijk}$ is the CSA of the selected primary

$\bar{X}_{hij}$ is the mean of the primary CSA's on the jth count tree.

$$b_1 = \frac{\sum\limits_{h,i}\left[\frac{1}{\sum\limits_i n_{hij}}\left[\sum\limits_j X_{hijk}\,\hat{Y}_{1(hijkL)} - \left(\sum\limits_j W_{hij}\,X_{hijk}\right)\left(\sum\limits_j Y_{1(hijkL)}\right)\right]\right]}{\sum\limits_{h,i}\left[\sum\limits_j W_{hij}\,X_{hijk}^2 - \left(\sum\limits_j W_{hij}\,X_{hijk}\right)^2\right]}$$

$$= \frac{\sum\limits_{h,i} S_{X_{hi}Y_{1(hi)}}}{\sum\limits_{h,i} S^2_{X_{hi}}} \quad \text{and} \quad W_{hij} = \frac{n_{hij}}{\sum\limits_j n_{hij}}$$

3. The three-stage regression estimate is:

$$\hat{Y}_{3(hi)} = \sum_j \hat{Y}_{3(hij)}$$

Where $\hat{Y}_{3(hij)}$ is the two-stage estimator of weight of good nuts per tree adjusted for differences in sum of primary CSA's between trees

$$\hat{Y}_{3(hij)} = \hat{Y}_{2(hij)} - b_2\,(X_{hij.} - \bar{X}_{hi.})\,, \quad \text{where}$$

Table 2.- Sample estimates by estimator and stratum for the 1970 survey, Oregon, August 1970

| Estimator | Sample estimate | Standard error | Estimate adjusted for undercount |
|---|---|---|---|
| | Tons | Tons | Tons |
| | | Stratum 4 * | |
| $\hat{Y}_1$ | 7357.2 | 698.22 | 8227.6 |
| $\hat{Y}_2$ | 7384.0 | 692.77 | 8257.5 |
| $\hat{Y}_3$ | 7165.2 | 686.61 | 8012.8 |
| | | Stratum 5 * | |
| $\hat{Y}_1$ | 148.7 | 37.13 | 166.3 |
| $\hat{Y}_2$ | 151.9 | 38.51 | 169.9 |
| $\hat{Y}_3$ | 161.1 | 40.55 | 180.2 |
| | | Stratum 6 * | |
| $\hat{Y}_1$ | 74.3 | 38.29 | 83.1 |
| $\hat{Y}_2$ | 73.4 | 38.94 | 82.1 |
| $\hat{Y}_3$ | 70.0 | 38.04 | 78.3 |
| | | Total | |
| $\hat{Y}_1$ | 7580.1 | 700.25 | 8476.8 |
| $\hat{Y}_2$ | 7609.3 | 694.93 | 8509.5 |
| $\hat{Y}_3$ | 7396.3 | 688.85 | 8271.3 |

*Stratum 4 are trees planted in 1959 or earlier; stratum 5, 1960-64; stratum 6, 1965 or later plantings.

$$b_2 = \frac{\sum_{h,i} \left[ \sum_j X_{hij.} \hat{Y}_{2(hij)} - \left( \sum_j X_{hij.} \right) \left( \sum_j \hat{Y}_{2(hij)} \right) / 3 \right]}{\sum_{h,i} \left[ \sum_j X_{hij.}^2 - \left( \sum_j X_{hij.} \right)^2 / 3 \right]}$$

$$= \frac{\sum_{h,i} S_{X_{hi}Y_{2(hi)}}}{\sum_{h,i} S^2_{X_{hi}}}$$

Table 2 shows the estimates produced for each of these estimators by strata and the standard error of each.

## F. Quality Control

A quality control check was made on five blocks (10 trees, 20 terminals). A total of 1724 nuts had been picked on the original survey. The quality control check yielded an additional 204 nuts. This would then be an undercount of (204/1724) x (100) = 11.83 percent. Table 2 also shows the three estimates adjusted for this undercount.

The variance of this ratio estimate (nuts missed/nuts picked) is very high as shown in the following computations.

$$\sigma^2_r = R^2 \ (1-f) \left( (V^2_x + V^2_y - 2\rho \ V_x \ V_y) \Big/ n \right)$$

Where $R$ = $Y/X$ = nuts missed/nuts picked

$$V^2_x = S^2_x/\bar{X}^2$$

$$V^2_y = S^2_y/\bar{Y}^2$$

$$\rho = \left(\sum^n (X_i - \bar{X})\ (Y_i - \bar{Y})\right)/(n-1)\ S_x S_y$$

This gave a $\sigma_r^2$ value of .0014 and a $\sigma_r$ of .0374. The sampling error is therefore $\frac{.0374}{.1183}$ = .3161 or 31.61 percent.

From Table 2 we can find the sampling error of $\hat{Y}_1$ for the total as

$$\frac{700.25}{7580.1} = .0924 \text{ or } 9.24 \text{ percent.}$$

The variance formula for the product of two variables is

$$\text{Var (AB)} = A^2 \text{ Var(B)} + B^2 \text{ Var(A)} - 2 \text{ AB Cov (AB)}.$$

If counting errors are not correlated with limb size, the covariance term drops out. The sampling error of $\hat{Y}_1$ adjusted for undercounting is

$$\frac{792.97}{8476.8} = .0935 \text{ or } 9.35 \text{ percent}$$

If there is a correlation between number of clusters and counting errors, this is an overstatement of sampling error.

The average number of nuts picked per terminal varied markedly between strata and also somewhat between nut types. The number of nuts picked per terminal ranged from zero in some of the younger trees to over 500 in older trees. The means for number of nuts picked are shown in Table 3.

Table 3.- Mean number of nuts picked per terminal and standard deviation, Oregon, August 1970

| Stratum | Nut type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Round | | | Oblong | | | Combined | | |
| | n | $\bar{x}$ | s.d. | n | $\bar{x}$ | s.d. | n | $\bar{x}$ | s.d. |
| 4 | 318 | 102.37 | 87.97 | 54 | 78.94 | 78.03 | 372 | 98.97 | 87.62 |
| 5 | 28 | 56.86 | 51.41 | 8 | 78.13 | 65.91 | 36 | 61.58 | 54.67 |
| 6 | 22 | 46.95 | 45.83 | 2 | 10.50 | 12.02 | 24 | 43.92 | 45.05 |
| All...... | 368 | 95.60 | 85.41 | 64 | 76.63 | 75.92 | 432 | 92.80 | 84.25 |

## G. Comparison of Old and New Sample Estimates

As was indicated in the introduction, the previous sampling procedure gave an estimate which was low compared to actual yields.

The old sample was selected using a geographic stratification. Blocks were selected proportional to size disregarding ages within each of the three areas (stratum). Within each selected block a semirandom procedure was used to locate a cluster of three sample trees. Generally, trees were located near the front of the orchard. One primary was selected on each tree and every 15th cluster of nuts was stripped using a random start. The 1970 design used a stratification by age of tree rather than a geographic stratification.

Tables 4 and 5 show the nested analysis of variance on expanded pounds of nuts per tree for the old and new sampling schemes at the tree level. The means for the two samples per tree for the old and new samples were 8.1836 and 11.3665 pounds per tree, respectively.

Table 4.- Nested AOV on pounds of nuts per tree for old sample, Oregon, August 1970

| Source | Degrees of freedom | Mean squares | F ratios | Variance components |
|---|---|---|---|---|
| Area | 2 | 33.3440 | .205 | -0.5272 |
| Block | 242 | 162.4560 | 2.602 | 33.3435 |
| Tree (primary) | 490 | 62.4253 | --- | 62.4253 |
| Total | 734 | 95.3260 | --- | ---- |

Table 5.- Nested AOV on pounds of nuts per tree for new sample, Oregon, August 1970

| Source | Degrees of freedom | Mean squares | F ratios | Variance components |
|---|---|---|---|---|
| Stratum | 2 | 1725.8096 | 6.931 | 55.0358 |
| Block | 69 | 249.0160 | 2.296 | 46.8488 |
| Tree (primary) | 144 | 108.4695 | --- | 108.4695 |
| Total | 215 | 168.6201 | --- | ---- |

An F test on the total variances gives a value of 1.7 which is significant at the .01 level. This difference would be expected because of the differences in means of the two estimates.

A higher variance might be expected at the tree level for the new sample because the three trees are randomly located within the block while the old procedure clustered the three trees selected. If any heterogeneity existed within the block, the mean square for trees would be larger. The sampling procedure of nuts from the tree may also add to the variance.

This may lead one to suspect lack of randomness or serious bias due to procedure for selecting trees and nuts in the old sampling procedure.

## V. Analysis of Size and Weight Change in Drying

The analysis of this part was concerned mainly with determining moisture content, distribution shift, and shrinkage or weight changes per nut.

### A. Moisture Content

The moisture content was determined at two different times. The first determination was at the time of sampling (green) and the second was when the samples were air dry. The air dry time was at about 10 percent moisture level for purposes of sizing and weighing. Table 6 shows the results of these findings.

Table 6.- Moisture content of green and air dried samples, Oregon, August 1970

| Type of nut | Samples | Nuts | Moisture | |
|---|---|---|---|---|
| | | | Green | Air dry |
| | Number | Number | Percent | Percent |
| Round | 36 | 703 | 51.24 | 9.22 |
| Elongate | 7 | 128 | 60.85 | 5.71 |
| Combined | 43 | 831 | 52.63 | 8.81 |

## B. Shrinkage in Drying

The nuts were sized and weighed three times to determine shrinkage in the drying process. The first time the nuts were sized and numbered green. The shrink in size of any single nut could then be measured from green to air dry or green to oven dry. The average shrink for all nuts was .82 mm. for green to air dry and 1.34 mm. for green to oven dry (see Table 7).

Table 7.- Overall average weight and size per nut at different stages of drying, Oregon, August 1970

| Type of nut | Average weight | | | Average size | | |
|---|---|---|---|---|---|---|
| | Green | Air dry | Oven dry | Green | Air dry | Oven dry |
| | Grams | Grams | Grams | Mm. | Mm. | Mm. |
| Round....... | 3.74 | 2.01 | 1.82 | 20.71 | 19.88 | 19.35 |
| Elongate.... | 3.46 | 1.44 | 1.35 | 18.34 | 17.61 | 17.15 |
| Combined.... | 3.69 | 1.92 | 1.75 | 20.35 | 19.53 | 19.01 |

The shift in distribution is shown pictorally in Graph 3 for round type nuts, in Graph 4 for elongate type nuts and in Graph 5 for the two nut types combined. Table 8 shows percent of nuts in each size group at each stage of drying for each type of nut.

The mean shift for each size group was computed for green to air dry and green to oven dry. This difference was computed by subtracting the mean size after drying from the original green size.

$$\bar{X}_j = \sum_i (\bar{X}_{ij} - \bar{X}'_{ij}) N_{ij} / \sum_i N_{ij}$$ = mean difference or shift in size over all samples for a particular size group.

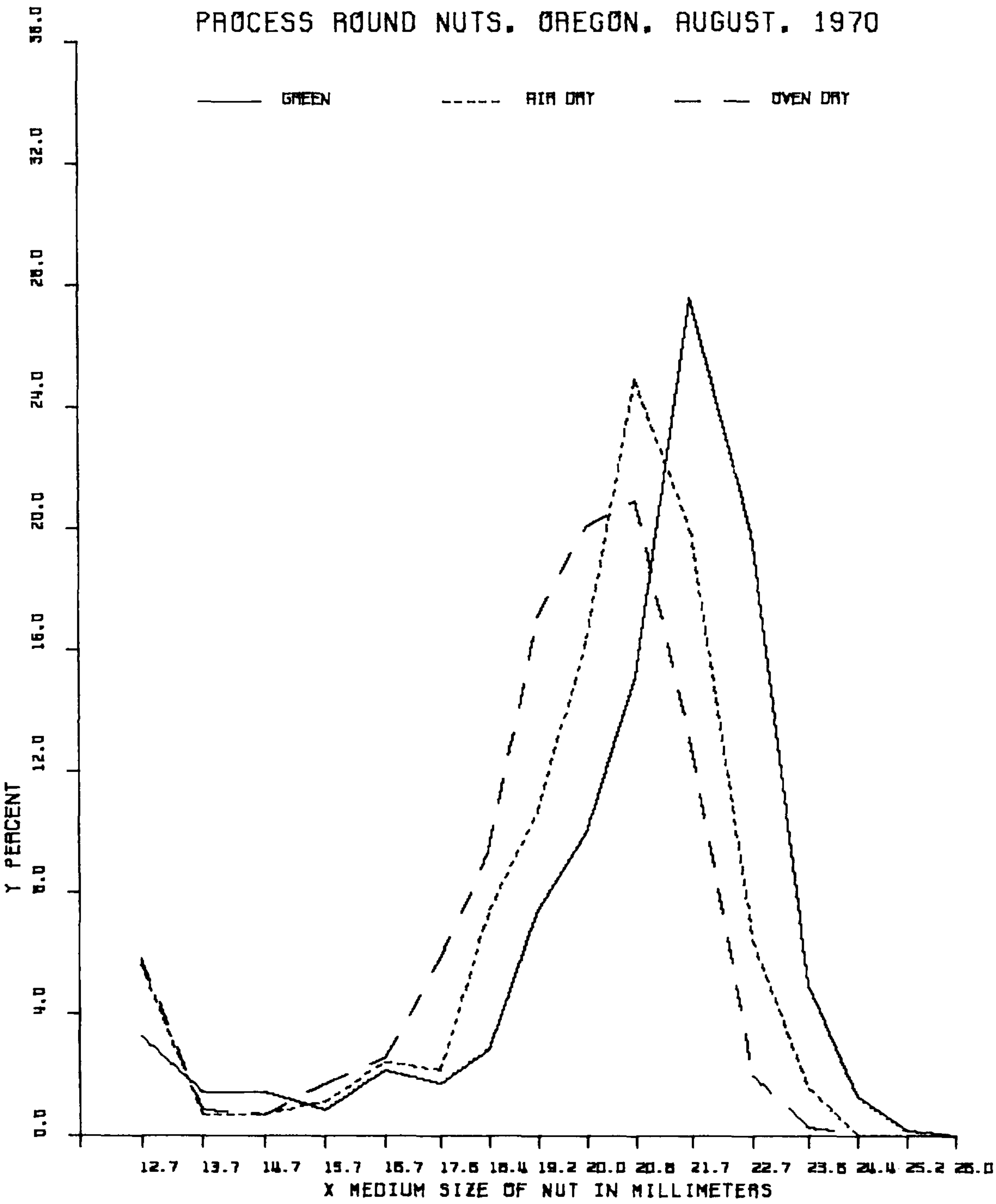
Where $\bar{X}_{ij} = \sum_j^{N_{ij}} X_{ij}/N_{ij}$ = green size

$\bar{X}'_{ij} = \sum_k (M_{ijk} X'_{ijk}) / N_{ij}$ = air dry or oven dry mean size.

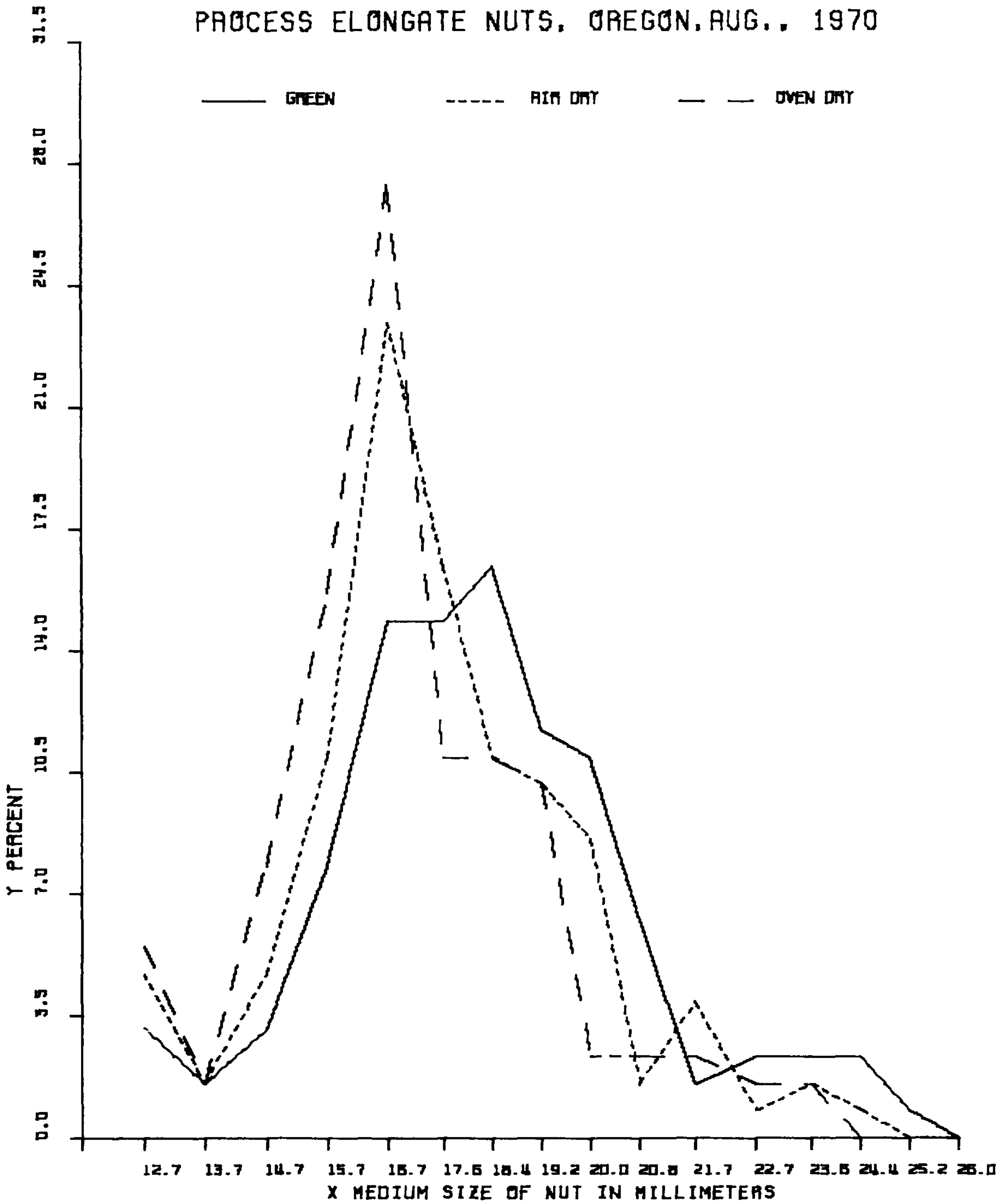
$N_{ij} = \sum_k M_{ijk}$ = number of nuts in a size group for a sample

Where $i$ = sample number
$j$ = green size
$k$ = air dry or oven dry size

GRAPH 3. DISTRIBUTION SHIFT IN DRYING PROCESS ROUND NUTS, OREGON, AUGUST, 1970



GRAPH 4. DISTRIBUTION SHIFT IN DRYING PROCESS ELONGATE NUTS, OREGON, AUG., 1970



GRAPH 5. DISTRIBUTION SHIFT IN DRYING PROCESS ALL NUTS, OREGON, AUGUST, 1970

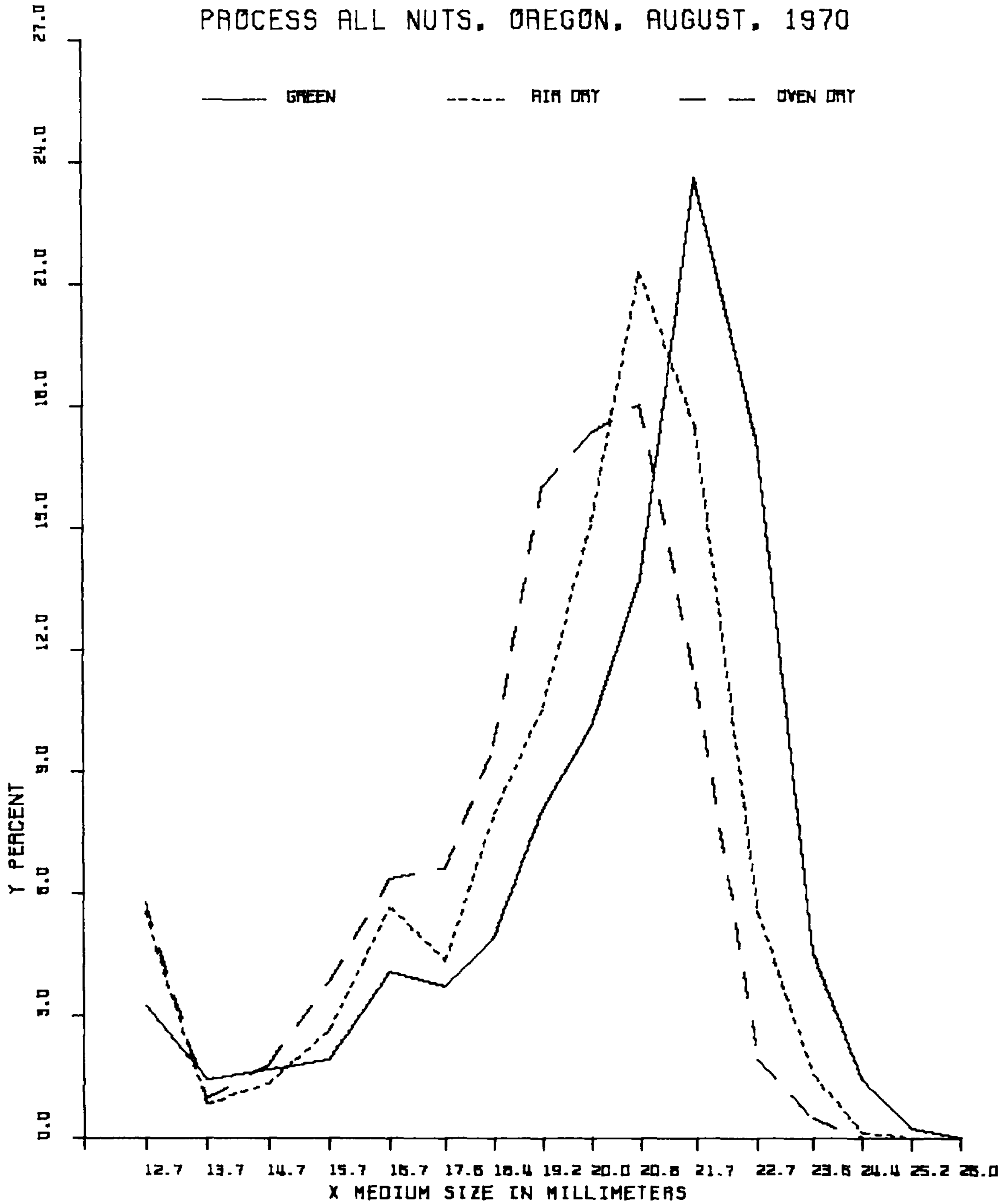


Table 8.- Percent of nuts in each size group at different stages of analysis, Oregon, August 1970

| Nut size | All nuts | | | Round nuts | | | Elongate nuts | | |
|---|---|---|---|---|---|---|---|---|---|
| | Green | Air dry | Oven dry | Green | Air dry | Oven dry | Green | Air dry | Oven dry |
| 1 | 3.25 | 5.54 | 5.78 | 3.27 | 5.69 | 5.83 | 3.13 | 4.69 | 5.47 |
| 2 | 1.44 | .84 | .96 | 1.42 | .71 | .85 | 1.56 | 1.56 | 1.56 |
| 3 | 1.69 | 1.32 | 1.80 | 1.42 | .71 | .71 | 3.13 | 4.69 | 7.81 |
| 4 | 1.93 | 2.65 | 3.85 | .85 | 1.14 | 1.71 | 7.81 | 10.94 | 15.62 |
| 5 | 4.09 | 5.66 | 6.38 | 2.13 | 2.42 | 2.56 | 14.84 | 23.44 | 27.34 |
| 6 | 3.73 | 4.33 | 6.62 | 1.71 | 2.13 | 5.83 | 14.84 | 16.41 | 10.94 |
| 7 | 4.93 | 7.94 | 9.63 | 2.84 | 7.40 | 9.39 | 16.41 | 10.94 | 10.94 |
| 8 | 8.06 | 10.59 | 16.00 | 7.40 | 10.67 | 17.07 | 11.72 | 10.16 | 10.16 |
| 9 | 10.11 | 15.16 | 17.33 | 9.96 | 16.36 | 20.06 | 10.94 | 8.59 | 2.34 |
| 10 | 13.72 | 21.30 | 18.05 | 15.08 | 24.89 | 20.91 | 6.25 | 1.56 | 2.34 |
| 11 | 23.59 | 17.45 | 11.19 | 27.60 | 19.92 | 12.80 | 1.56 | 3.91 | 2.34 |
| 12 | 17.21 | 5.54 | 1.93 | 19.91 | 6.40 | 1.99 | 2.34 | .78 | 1.56 |
| 13 | 4.57 | 1.56 | .48 | 4.98 | 1.56 | .28 | 2.34 | 1.56 | 1.56 |
| 14 | 1.44 | .12 | .00 | 1.28 | .00 | .00 | 2.34 | .78 | .00 |
| 15 | .24 | .00 | .00 | .14 | .00 | .00 | .78 | .00 | .00 |
| 16 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |

The variance between samples was also computed for each size group using the above data.

$$S^2_{(X_{ij} - X'_{ij})} = \frac{\sum_i (X_{ij} - X'_{ij})^2 - \frac{(\sum_i (X_{ij} - X'_{ij}))^2}{N_i}}{N_i \, (N_i - 1)}$$

where $N_i$ = number of samples in the ith size group.

A t-test was made for each size group to see if the shift in size was significant. The standard test for difference between two means was used as shown below.

$$t = \frac{\sum_i (X_{ij} - X'_{ij})}{N \, S_{(X_{ij} - X'_{ij})}}$$ = with N-1 degrees of freedom.

The t-tests were nearly all significant at the .01 level of probability. Tables 9 and 10 summarize the above results for the shrinkage in size from green to air dry and green to oven dry, respectively. A simple weighted regression analysis performed on the shrinkage figures shows a very good linear relationship. The amount of shrink increases as size increases. The correlation is much better when using the main size groups which include about 90 percent or more of the nuts. These main size groups are 4 through 14 for round type and both type of nuts combined. The elongate type nuts fall mainly in size groups 3 through 10. See Table 11 for a summarization of the correlation both ways. Graphs 6, 7, and 8 show the regression of shrink on green size for the main size groups.

Table 9.- Filbert shrinkage in size, green to air dry, Oregon, August 1970

| Green mean size in mm. | All nuts | | | | Round nuts | | | | Elongate nuts | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | $S_{(\bar{x}_{ij}-\bar{x}'_{ij})}$ | $\bar{X}_j$ | t-test | N | $S_{(\bar{x}_{ij}-\bar{x}'_{ij})}$ | $\bar{X}_j$ | t-test | N | $S_{(\bar{x}_{ij}-\bar{x}'_{ij})}$ | $\bar{X}_j$ | t-test |
| | | Mm. | Mm. | | | Mm. | Mm. | | | Mm. | Mm. | |
| 12.7 | 1/12 | | | | 1/ 9 | | | | 1/ 3 | | | |
| 13.7 | 8 | .0833 | .9167 | 11.00** | 7 | .0952 | .9048 | 9.50** | 1 | | 1.0000 | |
| 14.7 | 9 | .2693 | 1.1944 | 4.44** | 6 | .2016 | 1.6250 | 8.06** | 3 | .3333 | .3333 | 1.00 |
| 15.7 | 10 | .2568 | .9667 | 3.76** | 6 | .4014 | 1.1667 | 2.91* | 4 | .2041 | .6667 | 3.26* |
| 16.7 | 14 | .1342 | .5208 | 3.88** | 9 | .1909 | .5797 | 3.04* | 5 | .1687 | .4150 | 2.46 |
| 17.6 | 15 | .0604 | .8291 | 13.72** | 10 | .0900 | .8100 | 9.00** | 5 | .0370 | .8673 | 23.46* |
| 18.4 | 21 | .0944 | .6114 | 6.48** | 15 | .1244 | .5267 | 4.23** | 6 | .0612 | .8233 | 13.46** |
| 19.2 | 34 | .0736 | .6929 | 9.41** | 27 | .0818 | .6652 | 8.13** | 7 | .1746 | .8000 | 4.58** |
| 20.0 | 31 | .0494 | .7041 | 14.26** | 27 | .0498 | .7254 | 14.58** | 4 | .1904 | .5600 | 2.94 |
| 20.8 | 36 | .0528 | .7848 | 14.86** | 34 | .0558 | .7806 | 13.98** | 2 | .0571 | .8571 | 15.00** |
| 21.7 | 35 | .0517 | .8862 | 17.15** | 34 | .0517 | .8741 | 16.90** | 1 | | 1.3000 | |
| 22.7 | 32 | .0464 | 1.0277 | 22.15** | 31 | .0470 | 1.0189 | 21.66* | 1 | | 1.3000 | |
| 23.6 | 21 | .0956 | .9936 | 10.39** | 20 | .0886 | .9483 | 10.71** | 1 | | 1.9000 | |
| 24.4 | 9 | .0996 | .9037 | 9.07** | 8 | .1125 | .9125 | 8.11** | 1 | | .8333 | |
| 25.2 | 2 | .4500 | 2.0500 | 4.56 | 1 | | 2.5000 | | 1 | | 1.6000 | |
| 26.0 | - | | | | - | | | | - | | | |

1/ Nuts in this size group were too small to be considered marketable after shrinking.
* Significant at the five percent probability level.
** Significant at the one percent probability level.

Table 10.- Filbert shrinkage in size, green to oven dry, Oregon, August 1970

| Green mean size in mm. | All nuts | | | | Round nuts | | | | Elongate nuts | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | $S_{(x_{ij}-x'_{ij})}$ | $\bar{X}_j$ | t-test | N | $S_{(x_{ij}-x'_{ij})}$ | $\bar{X}_j$ | t-test | N | $S_{(x_{ij}-x'_{ij})}$ | $\bar{X}_j$ | t-test |
| | | Mm. | Mm. | | | Mm. | Mm. | | | Mm. | Mm. | |
| 12.7 | 1/ 12 | | | | 1/ 9 | | | | 1/ 3 | | | |
| 13.7 | 8 | .0417 | .9583 | 23.00** | 7 | .0476 | .9524 | 20.00** | 1 | | 1.0000 | |
| 14.7 | 9 | .2205 | 1.3333 | 6.05** | 6 | .2007 | 1.5833 | 7.89** | 3 | .4410 | .8333 | 1.89 |
| 15.7 | 10 | .2630 | 1.2833 | 4.88** | 6 | .4282 | 1.5000 | 3.50* | 4 | .0417 | .9583 | 23.00** |
| 16.7 | 14 | .1583 | .9661 | 6.10** | 9 | .2473 | 1.0056 | 4.07** | 5 | .0776 | .8950 | 11.53** |
| 17.6 | 15 | .1060 | 1.1122 | 10.50** | 10 | .1333 | 1.1000 | 8.25** | 5 | .1941 | 1.1367 | 5.86** |
| 18.4 | 21 | .0855 | 1.2364 | 14.46** | 15 | .1025 | 1.1150 | 10.88** | 6 | .0551 | 1.5400 | 27.93** |
| 19.2 | 34 | .0679 | 1.1916 | 17.55** | 27 | .0657 | 1.1536 | 17.55** | 7 | .2156 | 1.3381 | 6.21** |
| 20.0 | 31 | .0553 | 1.2120 | 21.93** | 27 | .0599 | 1.2138 | 20.26** | 4 | .1633 | 1.2000 | 7.35** |
| 20.8 | 36 | .0418 | 1.4220 | 34.03** | 34 | .0439 | 1.4182 | 32.28** | 2 | .1143 | 1.4857 | 13.00** |
| 21.7 | 35 | .0528 | 1.4716 | 27.85** | 34 | .0446 | 1.4414 | 32.30** | 1 | | 2.5000 | |
| 22.7 | 32 | .0651 | 1.5231 | 28.40** | 31 | .0660 | 1.5110 | 22.88** | 1 | | 1.9000 | |
| 23.6 | 21 | .0889 | 1.8119 | 20.37** | 20 | .0934 | 1.8075 | 19.35** | 1 | | 1.9000 | |
| 24.4 | 9 | .1054 | 1.5167 | 14.39** | 8 | .1184 | 1.5312 | 12.94** | 1 | | 1.4000 | |
| 25.2 | 2 | .4500 | 2.0500 | 4.56** | 1 | | 2.5000 | | 1 | | 1.6000 | |
| 26.0 | - | | | | - | | | | - | | | |

1/ Nuts in this size group were too small to be considered marketable after shrinking.
* Significant at the five percent probability level.
** Significant at the one percent probability level.

Table 11.- Correlation of green size with shrinkage after drying, Oregon, August 1970

| Nut sizes | All nuts | | Round nuts | | Elongate nuts | |
|---|---|---|---|---|---|---|
| | Air dry | Oven dry | Air dry | Oven dry | Air dry | Oven dry |
| Main 1/... | .8610 | .9266 | .8564 | .9335 | .5521 | .7714 |
| All....... | .3239 | .8185 | .1296 | .6995 | .6762 | .7475 |

1/ Main size classes exclude the few very large and very small nuts.

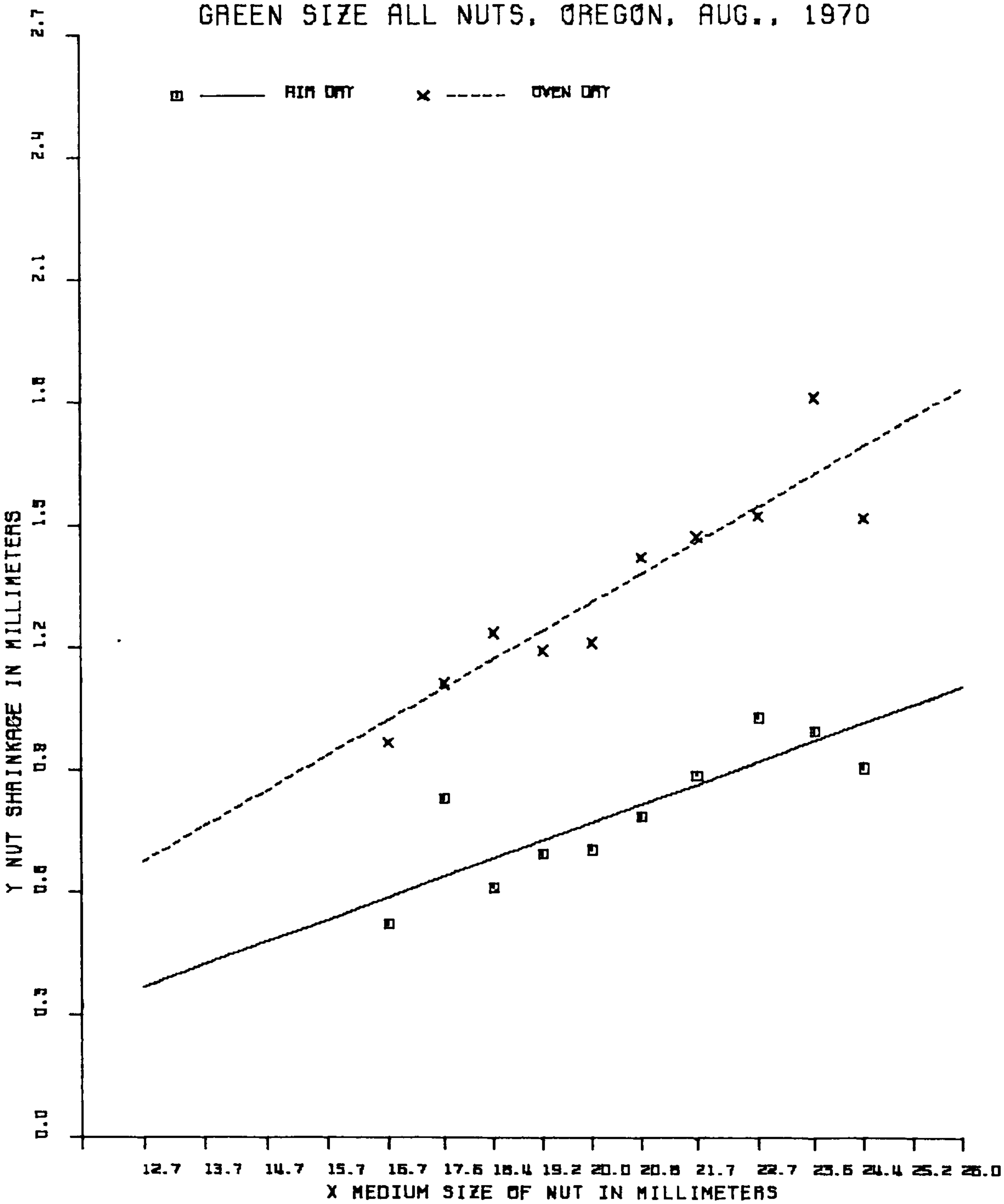
C. Weight Per Nut

The weight per nut is very highly correlated with size. Graph 9 summarizes the results obtained from a simple weighted regression analysis of weight per nut on size. The weight per nut for air dry and oven dry actually involves only the weight of the shell. When the shells were cracked at these two stages, it was found the nut had shriveled up almost completely, indicating very little dry matter had formed by the first part of August.

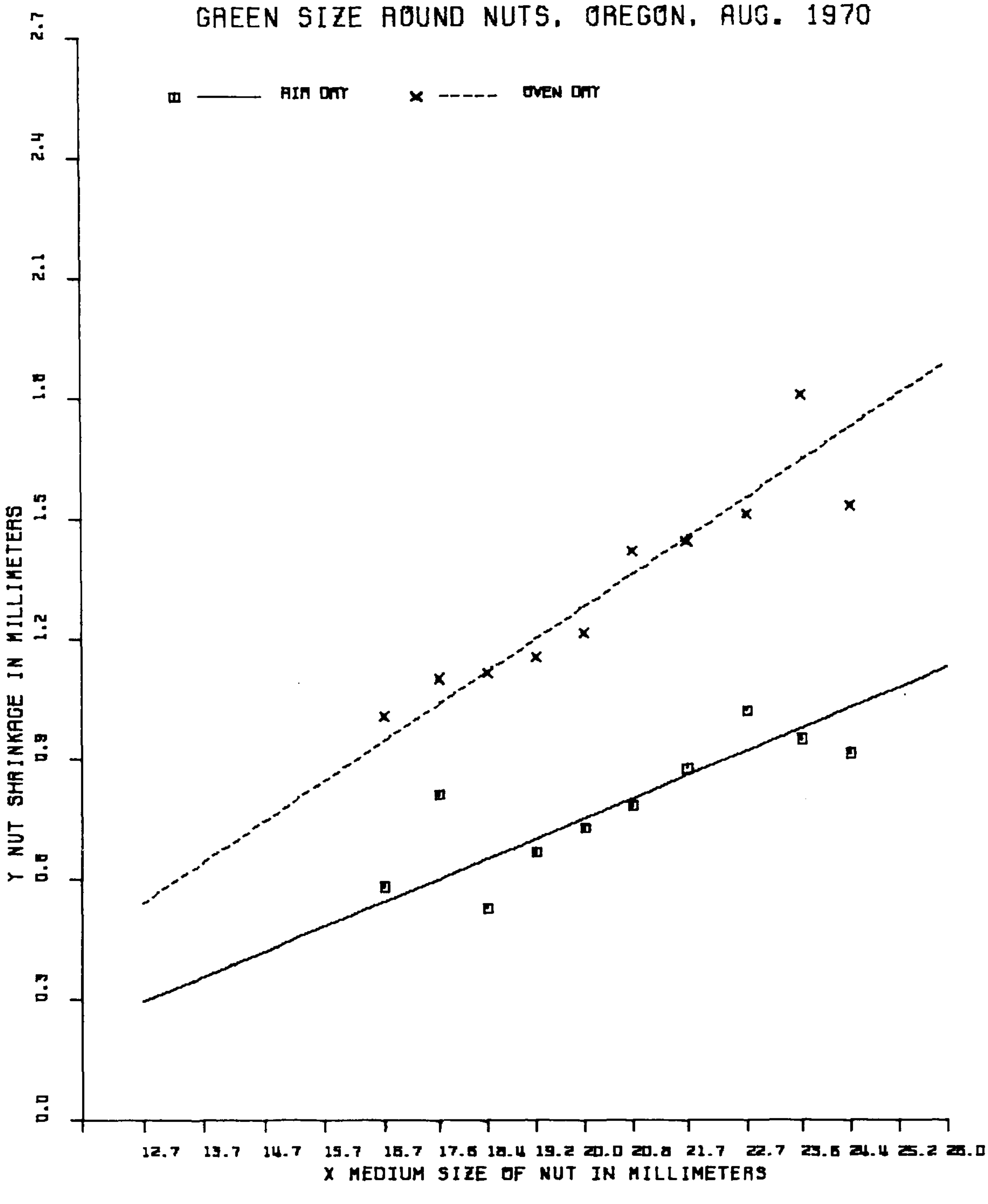
The actual weights per nut by size group at each stage of the analysis are shown in Table 12. Table 12 also shows the average weight per nut for all nuts at different stages of drying.

The total weight of nuts in the husk shows a very high correlation to total weight of husked nuts and number of nuts in sample. All nuts were not husked, so the subsample figures were expanded up to total sample size. The correlation matrix in Table 13 shows the correlations between the five variables used.

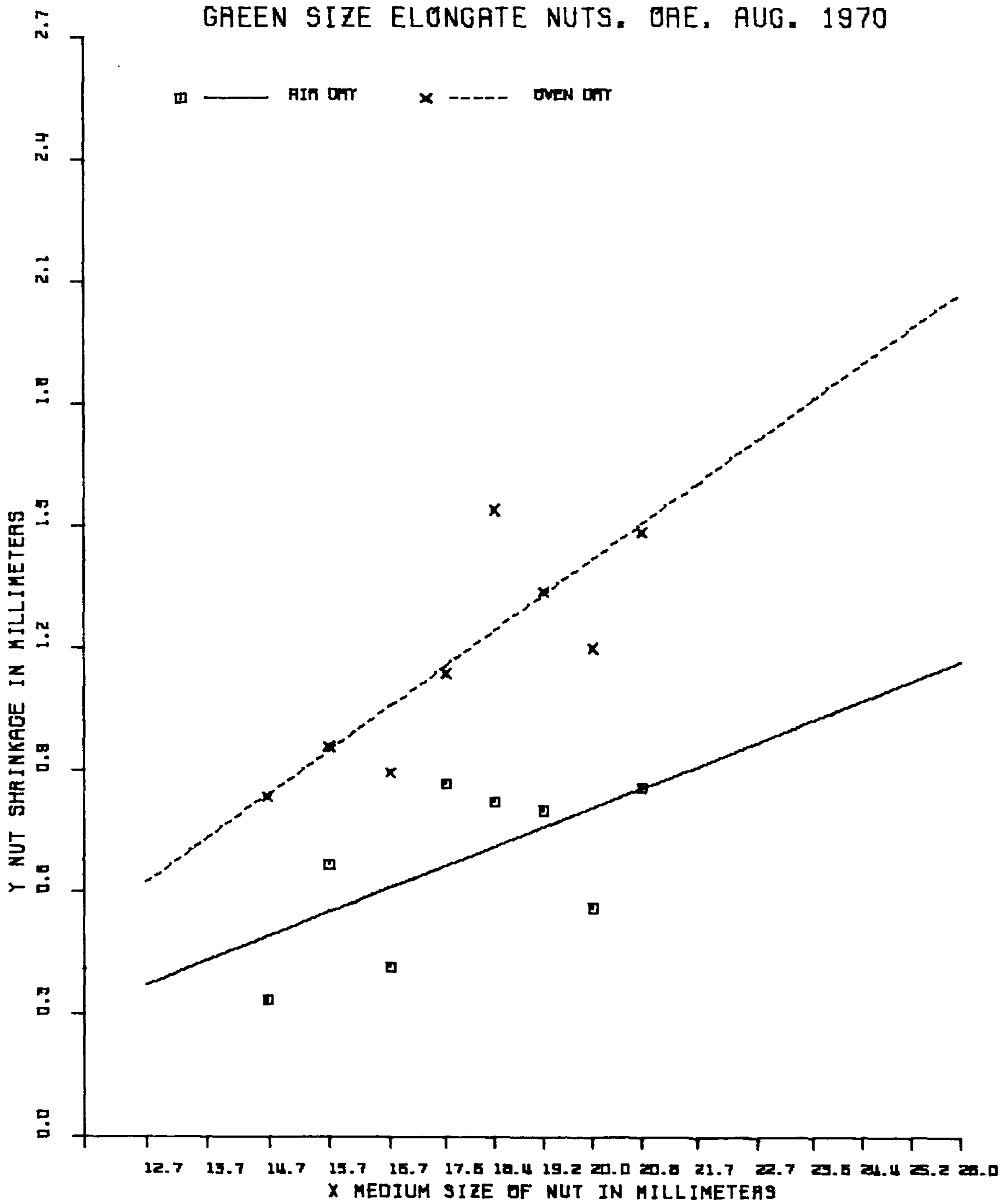
GRAPH 6. REGRESSION OF NUT SHRINKAGE ON GREEN SIZE ALL NUTS, OREGON, AUG., 1970



GRAPH 7. REGRESSION OF NUT SHRINKAGE ON GREEN SIZE ROUND NUTS, OREGON, AUG. 1970



GRAPH 8. REGRESSION OF NUT SHRINKAGE ON GREEN SIZE ELONGATE NUTS. ORE. AUG. 1970



GRAPH 9. REGRESSION OF WT/NUT ON SIZE AT DIFFERENT STAGES, OREGON, AUGUST 1970

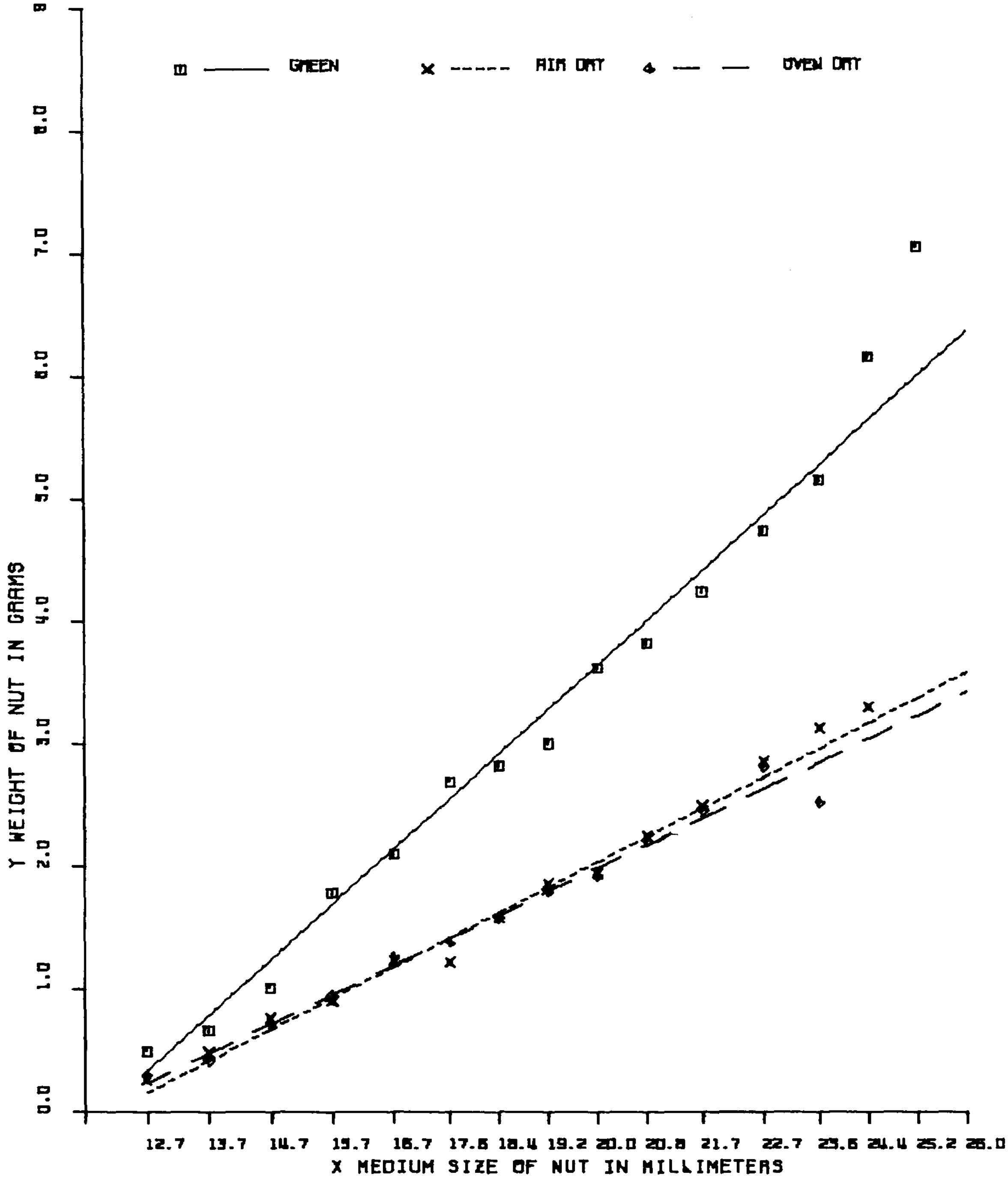


Table 12.- Weight per nut at different stages of analysis, by size group, Oregon, August 1970

| Nut size group | All nuts: Green | All nuts: Air dry | All nuts: Oven dry | Round nuts: Green | Round nuts: Air dry | Round nuts: Oven dry | Elongate nuts: Green | Elongate nuts: Air dry | Elongate nuts: Oven dry |
|---|---|---|---|---|---|---|---|---|---|
| | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams |
| 1 | .49 | .26 | .29 | .49 | .27 | .28 | .50 | .25 | .31 |
| 2 | .66 | .48 | .41 | .63 | .48 | .40 | .80 | .50 | .45 |
| 3 | 1.01 | .76 | .71 | .78 | .76 | .54 | 1.60 | .77 | .79 |
| 4. | 1.78 | .90 | .95 | 1.30 | .84 | .86 | 2.07 | .94 | 1.00 |
| 5 | 2.10 | 1.23 | 1.26 | 1.37 | 1.00 | 1.12 | 2.67 | 1.36 | 1.33 |
| 6 | 2.69 | 1.22 | 1.38 | 2.22 | 1.17 | 1.35 | 2.98 | 1.25 | 1.48 |
| 7 | 2.82 | 1.58 | 1.57 | 2.46 | 1.52 | 1.55 | 3.18 | 1.80 | 1.65 |
| 8 | 3.00 | 1.86 | 1.79 | 2.80 | 1.82 | 1.77 | 3.70 | 2.05 | 2.01 |
| 9 | 3.62 | 1.94 | 1.92 | 3.43 | 1.94 | 1.91 | 4.56 | 2.03 | 2.30 |
| 10 | 3.82 | 2.25 | 2.20 | 3.74 | 2.26 | 2.20 | 4.90 | 1.90 | 1.87 |
| 11 | 4.24 | 2.50 | 2.45 | 4.24 | 2.53 | 2.48 | 5.00 | 1.82 | 1.40 |
| 12 | 4.74 | 2.86 | 2.81 | 4.71 | 2.87 | 2.87 | 6.07 | 2.50 | 2.40 |
| 13 | 5.15 | 3.13 | 2.52 | 5.04 | 3.27 | 2.95 | 6.47 | 2.35 | 2.10 |
| 14 | 6.15 | 3.30 | - | 5.63 | - | - | 7.70 | 2.30 | - |
| 15 | 7.05 | - | - | 5.50 | - | - | 8.60 | - | - |
| 16 | - | - | - | - | - | - | - | - | - |
| Average per nut | 3.69 | 1.92 | 1.75 | 3.74 | 2.01 | 1.82 | 3.46 | 1.44 | 1.35 |

Table 13.- Correlation matrix of sample weights, Oregon, August 1970

| Variable | Unhusked weight | Husked weights | | | Number of nuts |
|---|---|---|---|---|---|
| | | Green | Air dry | Oven dry | |
| Unhusked weight | 1.000 | .993 | .985 | .990 | .973 |
| Green.......... | | 1.000 | .993 | .986 | .953 |
| Air dry........ | | | 1.000 | .979 | .951 |
| Oven dry....... | | | | 1.000 | .950 |
| Number of nuts. | | | | | 1.000 |

## VI. Preharvest Survey

The preharvest survey was conducted in late September and early October. Laboratory analyses were made the following week.

### A. Field Procedures

Blocks to be sampled were randomly selected from the blocks that were used to analyze the shrink data. Two trees were then selected to be sampled in each block. One tree was the same as used in the nut shrinkage study. The other tree was randomly chosen from the two remaining sample trees in the block.

The ground under each sample tree was divided into quarters or eighths depending on density of nuts on the ground. All nuts were gleaned from the portion most directly under the sample branch and placed in a bag. A sample terminal was then selected on the sample primary branch. All remaining nuts on this terminal were stripped and placed in a separate bag. The tree nuts at this time comprised only a small (two to five) percent of the total nuts.

### B. Laboratory Procedures

Any husks that remained on the nuts were removed. The total sample was then weighed and counted. Samples containing over 115-120 nuts were subsampled down to 100 nuts or less. The subsample (or the entire sample) was sized and weighed. All samples were oven dried, sized, and weighed again.

Throughout this process, tree nuts were kept separate from ground nuts. Table 14 shows the number of nuts processed.

Table 14.- Number of nuts processed in preharvest sample, Oregon, October 1970

| Type of nut | Number of nuts in sample | | |
|---|---|---|---|
| | Tree nuts | Ground nuts | Combined |
| All nuts.......... | 990 | 5410 | 6400 |
| Round nuts........ | 874 | 4998 | 5872 |
| Elongate nuts..... | 116 | 412 | 528 |

C. Moisture Content

The nuts still remaining in the trees contained 1.6 and 5.6 percent more moisture than ground nuts for elongate and round type nuts, respectively. Table 15 summarizes the data for moisture content.

D. Distribution of Nuts

The moisture content was not high, but the shrinkage that occurred during the drying process was still very significant. The size distributions of tree nuts and ground nuts were quite similar. The average loss in size over all size groups was about .6 mm. (Table 16). The distribution of the nuts is shown in Table 17 by percent in each size group for each type of nut and source (tree or ground) of nut. Graph 10 illustrates the shrinkage that occurred for each type of nut.

Table 15.- Moisture content, preharvest survey, Oregon, October 1970

| Type of nuts | Percent of moisture | | |
|---|---|---|---|
| | Tree nuts | Ground nuts | Combined |
| All nuts........... | 12.62 | 6.37 | 7.32 |
| Round nuts......... | 12.85 | 6.15 | 7.13 |
| Elongate nuts...... | 10.90 | 9.28 | 9.66 |

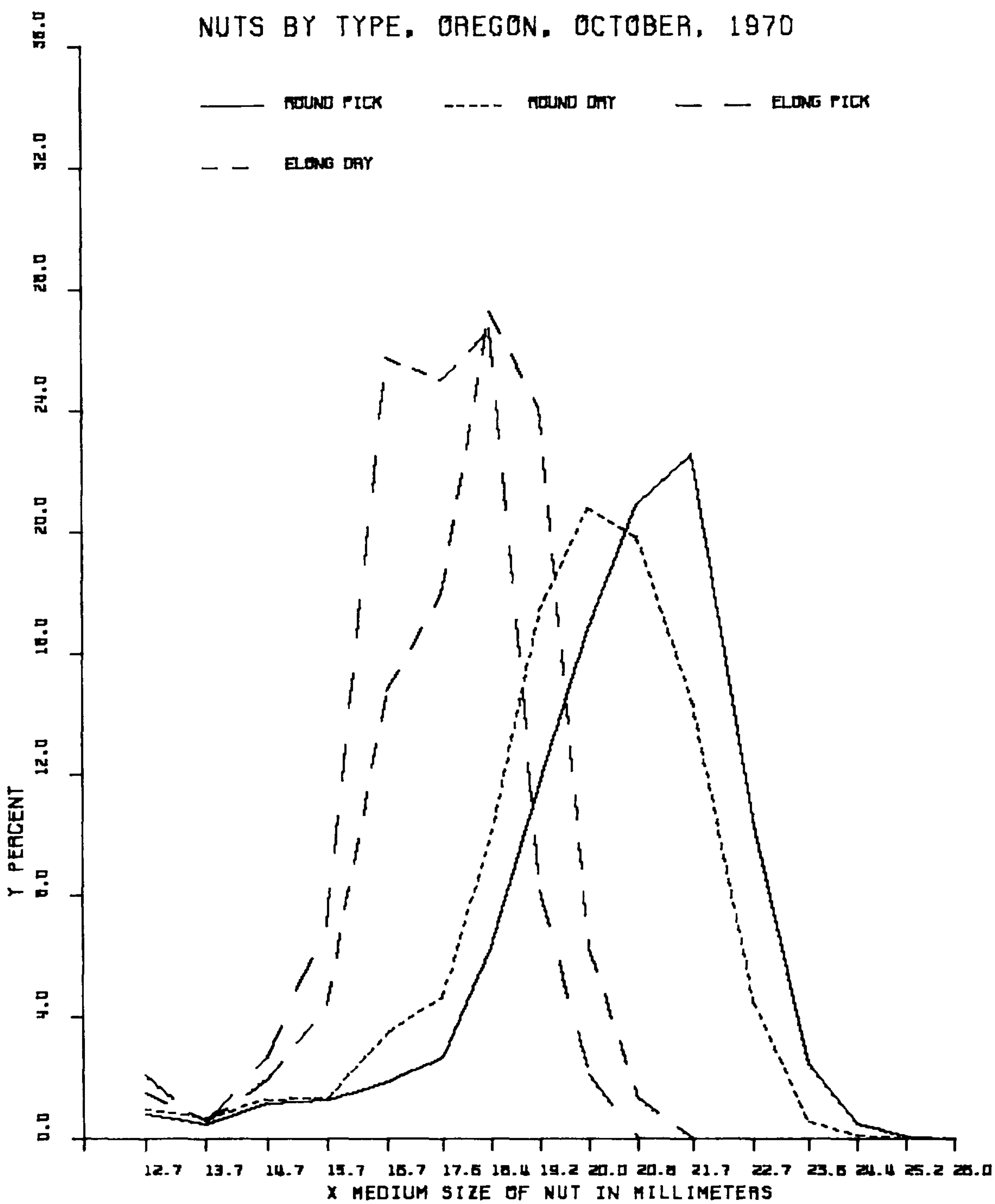
Table 16.- Overall mean size and loss in size during dry process, Oregon, October 1970

| Source of nuts | Round nuts | | | Elongate nuts | | |
|---|---|---|---|---|---|---|
| | Mean size | | Loss | Mean size | | Loss |
| | Picked | Dry | | Picked | Dry | |
| | Mm. | Mm. | Mm. | Mm. | Mm. | Mm. |
| Tree...... | 20.28 | 19.53 | -.65 | 18.16 | 17.60 | -.56 |
| Ground.... | 20.45 | 19.82 | -.63 | 17.99 | 17.38 | -.61 |
| Combined.. | 20.42 | 19.78 | -.64 | 18.03 | 17.43 | -.60 |

Table 17.- Size distribution of preharvest nuts in percent, Oregon, October 1970

| Nut size | Ground nuts | | | | Tree nuts | | | | All nuts | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | As picked | | Oven dried | | As picked | | Oven dried | | As picked | | Oven dried | |
| | Round | Elongate | Round | Elongate | Round | Elongate | Round | Elongate | Round | Elongate | Round | Elongate |
| 12.7 | .66 | 1.46 | .76 | 1.94 | 1.48 | 1.72 | 2.17 | 2.59 | .78 | 1.52 | .97 | 2.08 |
| 13.7 | .42 | .48 | .66 | .48 | .68 | .86 | .92 | .86 | .46 | .57 | .70 | .57 |
| 14.7 | 1.20 | 1.46 | 1.24 | 2.43 | .92 | 3.45 | 1.60 | 3.45 | 1.16 | 1.89 | 1.29 | 2.65 |
| 15.7 | 1.14 | 4.37 | 4.37 | 7.28 | 2.17 | 4.31 | 1.60 | 6.03 | 1.29 | 4.36 | 1.33 | 7.01 |
| 16.7 | 1.86 | 16.26 | 3.40 | 26.94 | 2.06 | 9.48 | 4.00 | 21.55 | 1.89 | 14.77 | 3.49 | 25.76 |
| 17.6 | 2.78 | 18.20 | 4.30 | 27.43 | 1.94 | 17.24 | 6.75 | 16.38 | 2.66 | 17.99 | 4.67 | 25.00 |
| 18.4 | 6.14 | 28.40 | 9.92 | 25.00 | 7.21 | 23.28 | 10.53 | 32.76 | 6.30 | 27.27 | 10.01 | 26.70 |
| 19.2 | 11.62 | 23.06 | 17.33 | 7.28 | 12.01 | 27.59 | 17.85 | 11.21 | 11.68 | 24.05 | 17.40 | 8.14 |
| 20.0 | 16.73 | 5.58 | 20.89 | 1.21 | 17.16 | 8.62 | 20.25 | 5.17 | 16.79 | 6.25 | 20.79 | 2.08 |
| 20.8 | 21.17 | .73 | 20.75 | - | 19.45 | 3.45 | 14.53 | - | 20.91 | 1.33 | 19.82 | - |
| 21.7 | 22.70 | - | 14.37 | - | 21.97 | - | 14.76 | - | 22.56 | - | 14.42 | - |
| 22.7 | 10.58 | - | 4.48 | - | 10.30 | - | 4.46 | - | 10.54 | - | 4.48 | - |
| 23.6 | 2.44 | - | .54 | - | 2.40 | - | .34 | - | 2.44 | - | .51 | - |
| 24.4 | .54 | - | .08 | - | .11 | - | .23 | - | .48 | - | .10 | - |
| 25.2 | .02 | - | - | - | .11 | - | - | - | .03 | - | - | - |
| 26.0 | .02 | - | - | - | - | - | - | - | .02 | - | - | - |

GRAPH 10. DISTRIBUTION OF PREHARVEST NUTS BY TYPE, OREGON, OCTOBER, 1970



## E. Weight Per Nut

A small weight loss occurred during the drying process. This varied from .18 grams to .32 grams per nut. The weight loss for each source and type of nut is shown in Table 18.

Table 18.- Overall weight per nut and loss of weight during drying process, Oregon, October 1970

| Source of nuts | Round nuts | | | Elongate nuts | | |
|---|---|---|---|---|---|---|
| | Weight per nut | | Loss | Weight per nut | | Loss |
| | As picked | Dry | | As picked | Dry | |
| | Grams | Grams | Grams | Grams | Grams | Grams |
| Tree........ | 2.73 | 2.41 | -.32 | 2.75 | 2.45 | -.30 |
| Ground...... | 2.83 | 2.65 | -.18 | 2.54 | 2.30 | -.24 |
| Combined.... | 2.82 | 2.62 | -.20 | 2.58 | 2.33 | -.25 |

The weight per nut by size groups, in many cases, showed higher average weights after the drying process (see Table 19). This occurred because the shrinkage in size was greater proportionally than the decrease in weight per nut causing many nuts to change size groups. Therefore, the average weight per nut for any particular size group went up during the drying process since nuts were not weighed in the same size group both times. This was particularly true for the round type nuts picked up from the ground. The other nuts showed a crossing point below which the weight per nut went up and above which weight per nut went down, evidently because the decrease in weight per nut for the larger size groups was greater.

The weight per nut for each type and condition by size groups is shown in Table 19. The behavior in the weights is shown graphically in Graphs 11, 12, and 13 for tree nuts, ground nuts and all nuts combined.

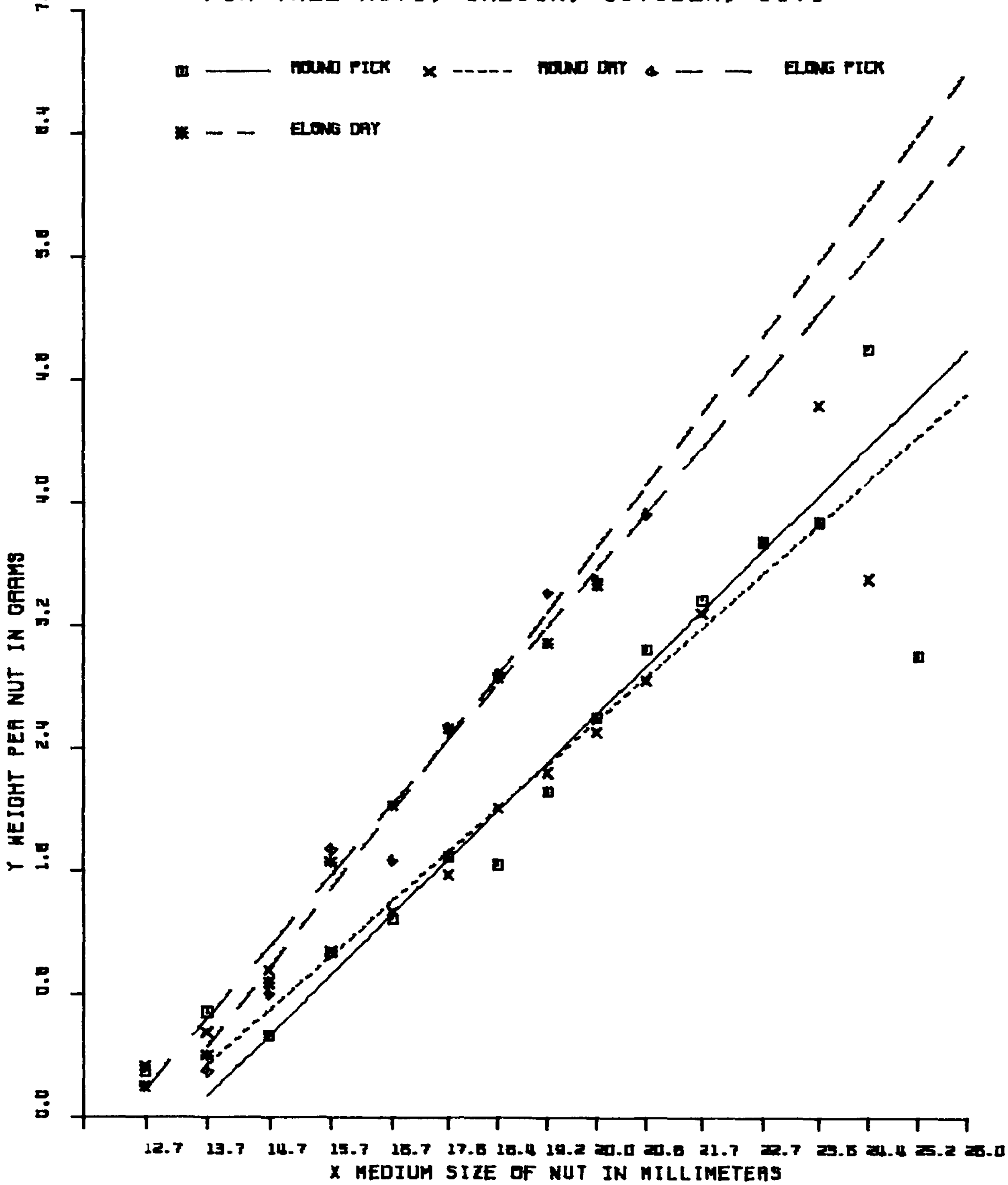
## F. Marketable Nuts

The defective nuts this year were mainly blanks with very few caused by brown spot, worms, etc. The good nut percents are 71.4 for round nuts and 86.2 for elongate nuts. These figures do not estimate amount harvested. In the harvesting process the smallest three sizes are blown over or left behind by the harvestors. If these three sizes are excluded, the theoretical harvested good nuts amount to 69.9 percent or 84.5 percent (see Table 20).

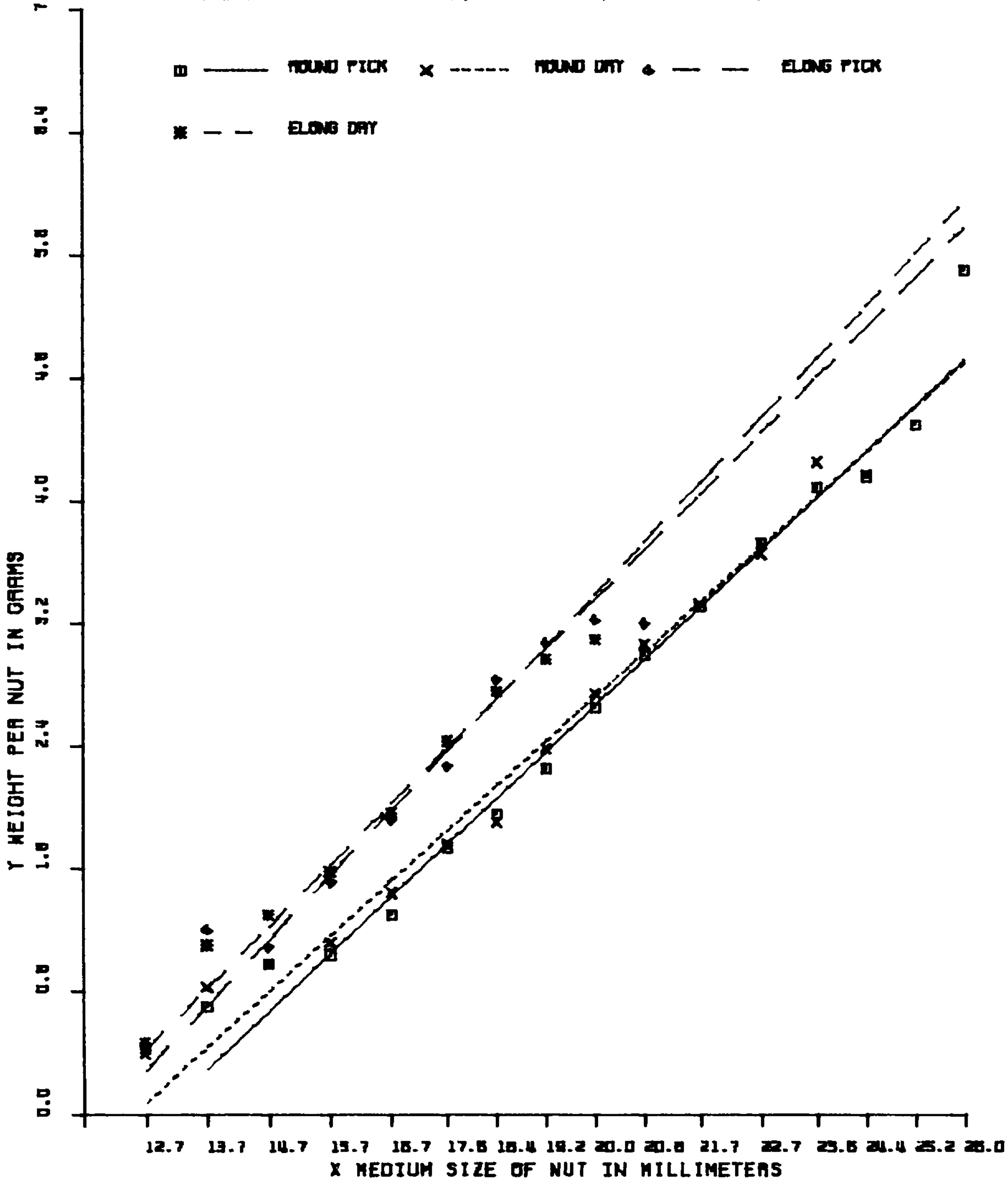
Table 19.- Preharvest weights per nut, Oregon, October 1970

| Nut size mm. | Round type nut | | | | | | Elongate type nut | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tree | | Ground | | Combined | | Tree | | Ground | | Combined | |
| | Picked | Dry | Picked | Dry | Picked | Dry | Picked | Dry | Picked | Dry | Picked | Dry |
| | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams | Grams |
| 12.7 | .300 | .326 | .421 | .392 | .387 | .370 | .200 | .200 | .417 | .462 | .362 | .391 |
| 13.7 | .683 | .550 | .700 | .824 | .696 | .770 | .300 | .400 | 1.200 | 1.100 | .900 | .867 |
| 14.7 | .525 | .957 | .980 | .979 | .926 | .975 | .800 | .875 | 1.083 | 1.300 | .970 | 1.178 |
| 15.7 | 1.074 | 1.086 | 1.035 | 1.112 | 1.045 | 1.107 | 1.740 | 1.657 | 1.511 | 1.580 | 1.561 | 1.594 |
| 16.7 | 1.289 | 1.329 | 1.298 | 1.440 | 1.296 | 1.421 | 1.664 | 2.024 | 1.916 | 1.965 | 1.881 | 1.976 |
| 17.6 | 1.694 | 1.575 | 1.740 | 1.760 | 1.735 | 1.720 | 2.530 | 2.526 | 2.268 | 2.431 | 2.323 | 2.445 |
| 18.4 | 1.643 | 2.013 | 1.958 | 1.904 | 2.061 | 1.904 | 2.881 | 2.861 | 2.836 | 2.761 | 2.844 | 2.788 |
| 19.2 | 2.115 | 2.239 | 2.253 | 2.381 | 2.232 | 2.359 | 3.412 | 3.085 | 3.077 | 2.967 | 3.161 | 3.002 |
| 20.0 | 2.595 | 2.505 | 2.652 | 2.745 | 2.643 | 2.710 | 3.490 | 3.467 | 3.226 | 3.100 | 3.306 | 3.300 |
| 20.8 | 3.045 | 2.842 | 2.997 | 3.068 | 3.003 | 3.043 | 3.925 | - | 3.200 | - | 3.614 | - |
| 21.7 | 3.368 | 3.280 | 3.310 | 3.333 | 3.319 | 3.325 | - | - | - | - | - | - |
| 22.7 | 3.743 | 3.741 | 3.724 | 3.659 | 3.727 | 3.671 | - | - | - | - | - | - |
| 23.6 | 3.871 | 4.633 | 4.089 | 4.256 | 4.057 | 4.294 | - | - | - | - | - | - |
| 24.4 | 5.000 | 3.500 | 4.159 | 4.175 | 4.189 | 3.950 | - | - | - | - | - | - |
| 25.2 | 3.000 | - | 4.500 | - | 3.750 | - | - | - | - | - | - | - |
| 26.0 | - | - | 5.500 | - | 5.500 | - | - | - | - | - | - | - |

GRAPH 11. REGRESSION OF WT/NUT ON SIZE
FOR TREE NUTS, OREGON, OCTOBER, 1970



GRAPH 12. REGRESSION OF WT/NUT ON SIZE
FOR GROUND NUTS, OREGON, OCTOBER, 1970



GRAPH 13. REGRESSION OF WT/NUT ON SIZE

ALL PREHARV NUTS, OREGON, OCTOBER, 1970

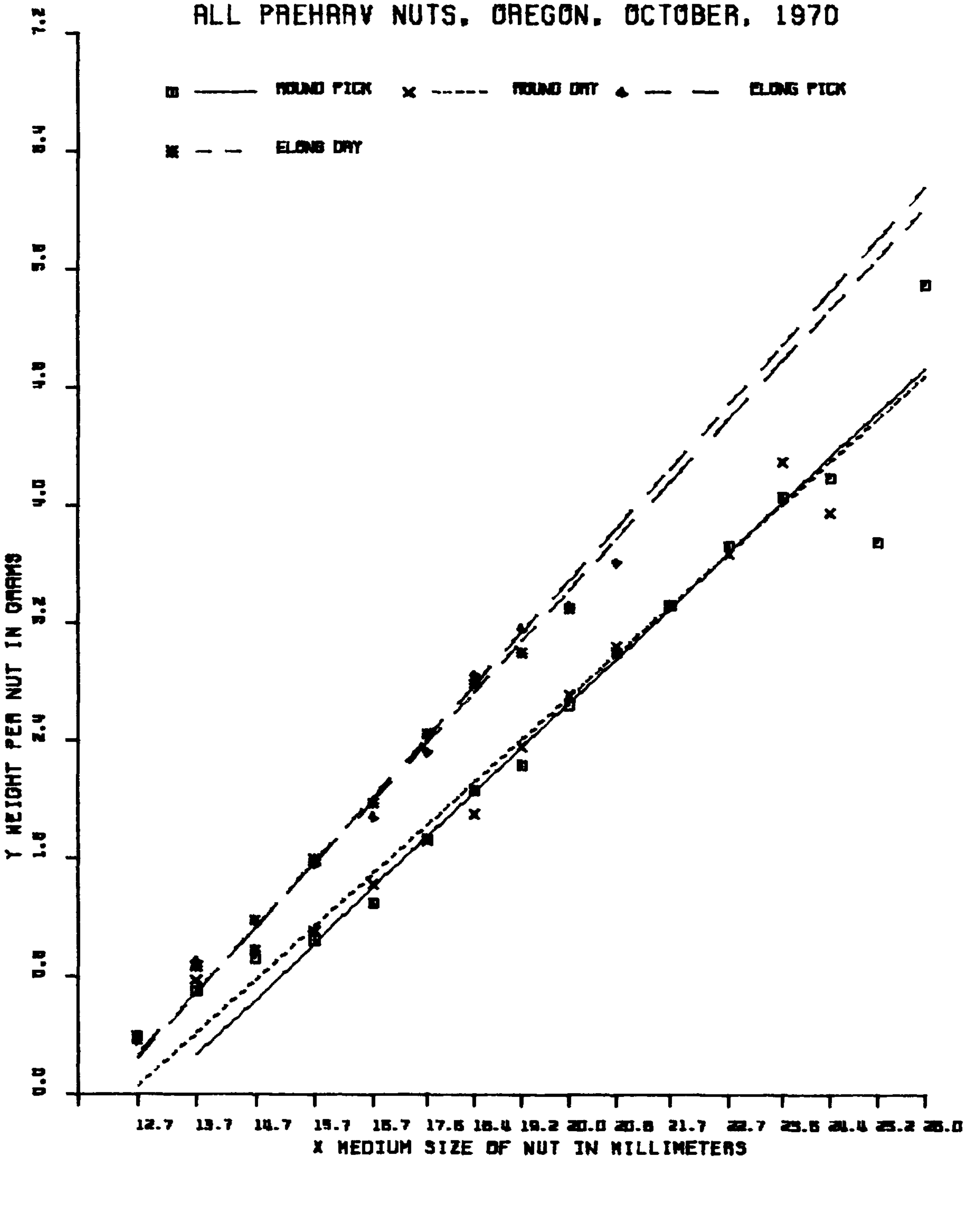


Table 20.- Percent of good nuts and harvestable good nuts, Oregon, October 1970

| Nut type | Tree nuts | | Ground nuts | | Combined | |
|---|---|---|---|---|---|---|
| | Good | Harvest | Good | Harvest | Good | Harvest |
| Round......... | 71.4 | 69.9 | 81.3 | 80.0 | 79.8 | 78.5 |
| Elongate...... | 86.2 | 84.5 | 85.9 | 84.2 | 86.0 | 84.3 |
| Combined...... | 73.1 | 71.6 | 81.6 | 80.3 | 80.3 | 79.0 |

## VII. Fall Packers Survey

### A. Procedures

A sample of nuts is obtained in the fall of each year from various packers, mainly to determine weight per good nut. However, the sample taken at each packing house is not random, and is probably from one or two of the growers who deliver that date.

These nuts are dried to about 10 percent moisture or less before sizing and cracking to check for defective nuts.

### B. Weight Per Good Nut

Weighted linear regression analyses were made on the data for each of the last three years. The analyses were weighted by the number of nuts in each size group. The weights per nut for each size group as determined by the regression are shown in Tables 21 and 22 for 1968, 1969, and 1970 for each type nut. The dependent variable was the weight per nut from the survey and the independent variable was the nut size in mm.

An analysis made on combined data for the three years showed there was no common regression coefficients for either nut type. The regression coefficients, however, only varied from .347 to .360 for the round type and from .299 to .360 for the elongate type. There were high correlations between the years. The weight per nut found by combining the three years data is also shown in Tables 21 and 22 for each nut type. This was also a weighted regression analysis. Each size group for each year was weighted by the number of nuts in that size group.

Table 21.- Weight per good nut by size group from Packers Survey as calculated by weighted linear regression analysis for elongate type nuts. The intercept (a), slope (b), and correlation (r) are also shown, Oregon, October 1970

| Size mm. | Combined three years | 1968 | 1969 | 1970 |
|---|---|---|---|---|
| | Grams | Grams | Grams | Grams |
| 12.7 | .777 | .734 | .763 | 1.086 |
| 13.7 | 1.129 | 1.034 | 1.123 | 1.393 |
| 14.7 | 1.480 | 1.333 | 1.483 | 1.699 |
| 15.7 | 1.831 | 1.632 | 1.842 | 2.005 |
| 16.7 | 2.182 | 1.931 | 2.202 | 2.311 |
| 17.6 | 2.498 | 2.200 | 2.525 | 2.587 |
| 18.4 | 2.779 | 2.440 | 2.813 | 2.832 |
| 19.2 | 3.060 | 2.679 | 3.101 | 3.077 |
| 20.0 | 3.340 | 2.919 | 3.388 | 3.322 |
| 20.8 | 3.621 | 3.158 | 3.676 | 3.567 |
| 21.7 | 3.937 | 3.427 | 4.000 | 3.842 |
| 22.7 | 4.288 | 3.726 | 4.359 | 4.148 |
| 23.6 | 4.604 | 3.996 | 4.683 | 4.424 |
| 24.4 | 4.885 | 4.235 | 4.971 | 4.669 |
| 25.2 | 5.166 | 4.474 | 5.258 | 4.914 |
| 26.0 | 5.447 | 4.714 | 5.546 | 5.159 |
| a | -3.6815 | -3.0654 | -3.8035 | -2.8023 |
| b | .3511 | .2992 | .3596 | .3062 |
| r | .9703 | .9956 | .9958 | .9887 |

Table 22.- Weight per good nut by size group from Packers Survey as calculated by weighted linear regression analysis for round type nuts. The intercept (a), slope (b), and correlation (r) are also shown, Oregon, October 1970

| Size mm. | Combined three years | 1968 | 1969 | 1970 |
|---|---|---|---|---|
| | Grams | Grams | Grams | Grams |
| 12.7 | .256 | .245 | .108 | .283 |
| 13.7 | .607 | .592 | .468 | .639 |
| 14.7 | .958 | .938 | .828 | .995 |
| 15.7 | 1.309 | 1.285 | 1.188 | 1.351 |
| 16.7 | 1.660 | 1.632 | 1.547 | 1.707 |
| 17.6 | 1.976 | 1.944 | 1.871 | 2.027 |
| 18.4 | 2.256 | 2.222 | 2.159 | 2.312 |
| 19.2 | 2.537 | 2.499 | 2.446 | 2.597 |
| 20.0 | 2.818 | 2.777 | 2.734 | 2.881 |
| 20.8 | 3.099 | 3.054 | 3.022 | 3.166 |
| 21.7 | 3.414 | 3.366 | 3.346 | 3.486 |
| 22.7 | 3.765 | 3.713 | 3.705 | 3.842 |
| 23.6 | 4.081 | 4.025 | 4.029 | 4.163 |
| 24.4 | 4.362 | 4.302 | 4.317 | 4.447 |
| 25.2 | 4.643 | 4.580 | 4.605 | 4.732 |
| 26.0 | 4.923 | 4.857 | 4.892 | 5.017 |
| a | -4.2000 | -4.1594 | -4.4597 | -4.2366 |
| b | .3509 | .3468 | .3597 | .3559 |
| r | .9861 | .9982 | .9926 | .9895 |

As discussed later in this report there were only eight size groups used in the 1971 survey. The average size of each of these eight groups was determined from a graph of the distribution of the nuts. This was done by arbitrarily combining size groups and/or parts of size groups and determining what the average size might be. These sizes were then used as the X-values in the regression formula determined for the combined data for the three years. Table 23 shows the weight per nut for eight size groups to be used in 1971.

Table 24 shows the adjusted weights that are to be used on the 1970 data for a ratio estimate. The sizes were adjusted downward to take into account the shrink which will occur from August 1 until harvest time. The adjusted sizes were then used as the X-values in the regression formula for the 1970 data. This adjustment of sizes was based on shrinkage data and the fall packers survey as reported in the "green size adjusted to dry size" section of this report. The first two sizes for round type nuts were entered as zero since no nuts are harvested in these size groups.

Table 23.- Weight per good nut for 1971 Packers Survey based on data for the past three years, Oregon, October 1970

| Round type | | Elongate type | |
|---|---|---|---|
| Medium size | Weight | Medium size | Weight |
| Mm. | Grams | Mm. | Grams |
| 13.20 | .432 | 13.20 | .953 |
| 17.04 | 1.779 | 16.87 | 2.242 |
| 18.87 | 2.421 | 18.78 | 2.912 |
| 19.88 | 2.776 | 19.79 | 3.267 |
| 20.90 | 3.134 | 20.90 | 3.656 |
| 21.80 | 3.450 | 21.80 | 3.972 |
| 22.70 | 3.765 | 22.70 | 4.288 |
| 23.67 | 4.106 | 24.80 | 5.026 |

Table 24.- Adjusted weights per good nut to allow for shrinkage in size from August 1 until harvest time, Oregon, October 1970

| Size | | 1970 weights | |
|---|---|---|---|
| As sized | Adjusted for shrink | Round | Elongate |
| Mm. | Mm. | Grams | Grams |
| 12.7 | 12.30 | .000 | .964 |
| 13.7 | 13.30 | .000 | 1.270 |
| 14.7 | 14.30 | .853 | 1.576 |
| 15.7 | 15.30 | 1.209 | 1.882 |
| 16.7 | 16.30 | 1.565 | 2.189 |
| 17.6 | 17.15 | 1.867 | 2.449 |
| 18.4 | 17.90 | 2.134 | 2.679 |
| 19.2 | 18.80 | 2.454 | 2.954 |
| 20.0 | 19.50 | 2.703 | 3.169 |
| 20.8 | 20.25 | 2.970 | 3.398 |
| 21.7 | 21.10 | 3.273 | 3.658 |
| 22.7 | 22.30 | 3.700 | 4.026 |
| 23.6 | 23.20 | 4.020 | 4.302 |
| 24.4 | 24.00 | 4.305 | 4.546 |
| 25.2 | 24.80 | 4.590 | 4.791 |
| 26.0 | 25.60 | 4.874 | 5.036 |

## VIII. Recommendations for 1971

### A. Neyman Allocation of Blocks

The present number of blocks in the sample (72) gave a c.v. (coefficient of variation) for pounds of good nuts per tree of .0923. A larger sample is needed to reduce this and obtain more precision. Doubling the size of the sample for this next year (1971) was about all the state office could handle. A Neyman allocation was run using the data obtained in 1970 in order to best allocate the additional blocks.

The variance for each stratum was computed on the block estimate or sum total of three trees. This was an estimate of pounds of good nuts being produced by the three sample trees in the block. The allocation was determined by using

$$n_h = \frac{N_h \ S_{x'_h}}{\sum_h N_h \ S_{x'_h}} n$$

$$\text{where } S^2_{x'_h} = \frac{\sum_j x_{hi}^2 - n_h \bar{x}'^2_h}{n_h - 1}$$

$N_h$ = number of trees

$n$ = number of blocks

$i$ = 1, 2, . . . , number of blocks

$h$ = 1, 2, 3 number of strata

$x_{hi}$ = estimate of pounds of good nuts for ith block of hth stratum

$\bar{x}'_n$ = estimate of average pounds of good nuts per block in hth stratum

The Neyman allocation found above was compared to a stratified proportionate sample found using

$$n_h = \frac{N_h}{N} n$$

The final allocation of sample blocks was based on a compromise of the two allocations. The variance of the sample mean estimated from a stratified sample was used to compare the variances under the different allocations. The variance of the sample mean was arrived at in the following steps.

$$x' = \frac{1}{3} \sum_h N_h \bar{x}'_h$$

where $\bar{x}'_h = \sum_i \sum_j \frac{x_{hij}}{n_h}$

$j = 1, 2, 3$ number of trees/block

$n_h$ = number of sample blocks in the hth age class

$$S_{x'}^2 = \frac{1}{9} \sum_h N_h^2 \, S_{\bar{x}'_h}^2 = \frac{1}{9} \sum_h N_h^2 \frac{S_{x'_h}^2}{n_h}$$

$$S_{\bar{x}'}^2 = \frac{S_{x'}^2}{N^2/9}$$

Table 25 gives the results of the different allocations and a comparison of the variances. A weighted mean of 30.66 was used to determine the coefficient of variation (c.v.) of the mean which is also shown in the same table. The c.v. is reduced by about one-third and the variance of the mean is reduced by more than one-half in doubling the sample size under the compromise allocation.

Table 25.- Allocations and variances used to determine sample distribution to expand sample size for 1971

| Strata | $\bar{x}'_h$ | $S_{x'_h}^2$ | $S_{\bar{x}'_h}^2$ | $n_h$ (blocks of three trees) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1970 | Neyman | Proportionate | 1971 |
| 4 | 38.91 | 843.91 | 13.61 | 62 | 150 | 119 | 140 |
| 5 | 5.63 | 11.99 | 2.00 | 6 | 3 | 16 | 8 |
| 6 | 2.25 | 5.50 | 1.37 | 4 | 2 | 20 | 7 |
| $S_{\bar{x}'}^2$ | | | | 8.01 | 3.38 | 4.16 | 3.56 |
| $V_{\bar{x}'}$ | | | | .0923 | .0600 | .0665 | .0615 |

The size of sample necessary to obtain results of a given precision can be determined by using

$$n = \frac{k^2\ V^2\ N}{ND^2 + k^2\ V^2} = \frac{k^2\ V^2}{D^2} \quad \text{in large populations}$$

where D = relative error allowed

$V^2$ = rel-variance

k = risk of being wrong

1 = 1 in 3

2 = 1 in 20

3 = 3 in 1000

For 1970 the relative error which occurred with the 72 samples could be computed as follows:

$n = 72 \qquad V^2 = n\ V_x^{\ 2} = (72)\ (.0085) = .612$

$k = 2$ (which says we want to be right 95 percent of the time)

$$D^2 = \frac{k^2\ V^2}{n} = \frac{(4)\ (.612)}{72} = .034 \qquad D = .18439$$

Therefore the relative error was 18.439 percent. Under the same conditions in 1971 the relative error will be 12.33 percent.

## B. Optimum Allocation of Terminals and Trees

Optimization was done assuming simple random sampling with equal probability of selection at all stages. The variance components were computed from sample data selected. Table 26 shows the variance components and mean squares used in the optimization.

Table 26.- Nested analysis of variance on expanded estimates (lbs/tree) to tree level by terminal, Oregon, August 1970

| Source of variation | Degrees of freedom | Mean squares | F ratios | Components of variance |
|---|---|---|---|---|
| Stratum | 2 | 3451.312 | 6.929 | 55.029 |
| Block | 69 | 498.075 | 2.296 | 46.855 |
| Tree | 144 | 216.942 | 2.004 | 54.342 |
| Terminal | 216 | 108.257 | | 108.257 |
| Total | 431 | 222.490 | | |

The appropriate cost function is:

$$C = C_S(k) + C_B\,(kb) + C_P\,(kbp) + C_T\,(kbpt)$$

where k = number of strata in sample
b = number of blocks per strata in sample
p = number trees per block in sample
t = number of terminals per tree in sample

$C_S$ is cost of stratification

$C_B$ is cost of going from block to block (or block to home)

$C_P$ is cost of locating tree and primary within tree

$C_T$ is cost of stripping terminal, bagging nuts, recording, sizing, weighing, cracking and peeling

According to Snedecor and Cochran 1/, the optimum values for p and t are:

1/ George W. Snedecor and William G. Cochran, "Statistical Methods," Iowa St., Univ. Press, Ames, Sixth ed., 1967, pages 532-533.

$$t = \sqrt{\frac{C_P}{C_T}\,\frac{S_T^2}{S_P^2}} \qquad p = \sqrt{\frac{C_B}{C_P}\,\frac{S_P^2}{S_B^2}}$$

where $S_T^2$ is variance component between terminals within trees (primaries)

$S_P^2$ is variance component between trees

$S_B^2$ is variance component between blocks

The costs for the different components were estimated as

$C_B$ = 190 minutes $\qquad$ $C_P$ = 20 minutes $\qquad$ $C_T$ = 50 minutes

The costs in the field involve the presence of two enumerators at all times to do the sampling. The cost per terminal involves laboratory work of sizing and weighing as well as field time.

The optimum values rounded to integers are:

t = 1 terminal
p = 3 trees

Previous (1969) research had shown optimum values of 3 trees and 2 terminals selected from one primary on each tree. Laboratory operations had not been considered in the previous optimization calculations.

## C. Subsample of Nuts for Lab Analysis

The proportion of nuts estimated in each size group was used in the binomial form to find an estimated variance of weight per nut within terminals. The overall variance of pounds per tree can be broken down into two parts which are the between terminal variance and within terminal variance within the tree.

$$\sigma^2 = \sigma_b^2 + \sigma_w^2$$

$$= \sigma_b^2 + \frac{\sigma_x^2}{\bar{n}}\,\frac{\bar{N}-\bar{n}}{\bar{N}}$$

The variance of x was determined in the following procedure where $X_i$ is the grams of nuts per tree and $x_i$ is the estimated grams of nuts per tree.

$$X_i = \sum_j N_{ij} w_j = N_i \sum_j p_j w_j \qquad p_j = \frac{N_{ij}}{N_i}$$

$$x_i = N_i \sum_j \hat{p}_j w_j$$

where $w_j$ = average weight per nut for jth size group

$\hat{p}_j$ = estimated proportion in jth size group

$$E(x_i) = E(N_i \sum_j \hat{p}_j w_j) = N_i \sum_j p_j w_j$$

$$\left[E(x_i)\right]^2 = N_i^2 \left[\sum_j w_j^2 p_j^2 + \sum_{i \neq j} w_i w_j p_i p_j\right]$$

$$E(x_i^2) = E\left[N_i \sum_j \hat{p}_j w_j\right]^2$$

$$= E\left[N_i^2 \sum_j (\hat{p}_j w_j)^2 + N_i^2 \sum_{i \neq j} \hat{p}_i \hat{p}_j w_i w_j\right]$$

$$= N_i^2 \sum_j w_j^2 \; E(\hat{p}_j)^2 + N_i^2 \sum_{i \neq j} w_i w_j \; E(\hat{p}_i \hat{p}_j)$$

$$= N_i^2 \sum_j w_j^2 (\sigma_p^2 + p^2) + N_i^2 \sum_{i \neq j} w_i w_j (\sigma p_i p_j + p_i p_j)$$

Then, the $\sigma_x^2 = E(x_i)^2 - \left[E(x_i)\right]^2$

$$= N_i^2 \left[\sum_j w_j^2 \; \sigma p_j^2 + \sum_{i \neq j} w_i w_j \; \sigma p_i p_j\right]$$

Where $\sigma p_j^2 = \dfrac{p_j (1-p_j)}{n}$ which is the pure form not allowing for variation in sample size. The finite correction factor is added when used in the overall variance formula.

The total variance was obtained from a nested analysis of variance on the pounds of nuts per tree as shown in Table 27. The between variance was then obtained by subtraction.

Table 27 gives the total variance as 108.257 and the within variance computes as .014. The between variance therefore accounts for practically all of the total variance.

Table 27.- Nested analysis of variance of nuts per tree estimates, Oregon, August 1970

| Source of variation | Degrees of freedom | Mean squares | F ratios | Components of variance |
|---|---|---|---|---|
| Age stratification.......... | 2 | 3451.312 | 6.929 | 55.029 |
| Block........... | 69 | 498.075 | 2.296 | 46.855 |
| Tree (primary).. | 144 | 216.942 | 2.004 | 54.342 |
| Terminal........ | 216 | 108.258 | | 108.258 |
| Total........... | 431 | 222.490 | | |

The size group containing the smallest number of nuts in it had a proportion of .03697. The reciprocal of this number would be the number of nuts needed in a subsample in order to expect at least one nut in this size group. The number of nuts needed in the subsample would be 27. It is therefore recommended that a minimum of about 30 nuts be selected for any particular subsample.

The variance formula for the variance of $p_j$ can be used to find subsample rates for varying size of samples.

$$\sigma_{p_j}{}^2 = \frac{p_j\ (1-p_j)}{n}\ \frac{N-n}{N}$$

If we use N = 100 and n = 50 as an arbitrary starting point and any one of the $p_j$ values (.03697), a variance can be determined on which to base the subsampling rate. Using these values we would get a variance of .000356 for $p_j$.

Solving for n we get

$$n = \frac{p_j \ (1-p_j)}{N \ \sigma_{p_j}{}^2 + p_j \ (1-p_j)}$$

Table 28 shows various sample sizes and the suggested subsample size for each.

Table 28.- Size of subsample suggested for nuts stripped from a single terminal, Oregon, August 1970

| N sample | n subsample | N sample | n subsample |
|---|---|---|---|
| 30 | all | 225 | 69 |
| 40 | 30 | 250 | 71 |
| 50 | 33 | 275 | 73 |
| 60 | 37 | 300 | 75 |
| 70 | 41 | 350 | 78 |
| 80 | 44 | 400 | 80 |
| 90 | 47 | 450 | 82 |
| 100 | 50 | 500 | 83 |
| 125 | 55 | 550 | 85 |
| 150 | 60 | 600 | 86 |
| 175 | 64 | 1000 | 91 |
| 200 | 67 | 2000 | 95 |

## D. Recommended Change in Size Groups

The present number of size groups is sixteen. The following recommendations will reduce this number to seven or eight size groups. The "United States Standards for Grades of Filberts in the Shell" dated July 14, 1970 from the Consumer and Marketing Service listed the size classifications as shown in Table 29.

Table 29.- Size classifications for round type varieties as set by USDA, July 4, 1970

| Size classifications | Maximum size | Minimum size |
|---|---|---|
| | Will pass through a round opening of the following size | Will not pass through a round opening of the following size |
| Jumbo | No maximum | 22.2 mm |
| Large | 22.2 mm | 19.4 mm |
| Medium | 19.4 mm | 17.9 mm |
| Small | 17.9 mm | No minimum |

The size classifications set by USDA were used as a guide in recommending the new size groups. The elongate type varieties comprise less than ten percent of the total nuts harvested. The industry or packers tend to size all nuts according to the round type classification since the other type makes up such a small percent of the total. The changes recommended here then apply to both nut types.

The data collected after harvest from the packers show that there are no harvested round type nuts of the present sizes 1 and 2. Evidently most of these are defects or so light in weight that they are blown over by the harvestors used in the orchards. Therefore, at the time of the August survey it is recommended that these small round type nuts be discarded since they do not show up in the final harvest anyway.

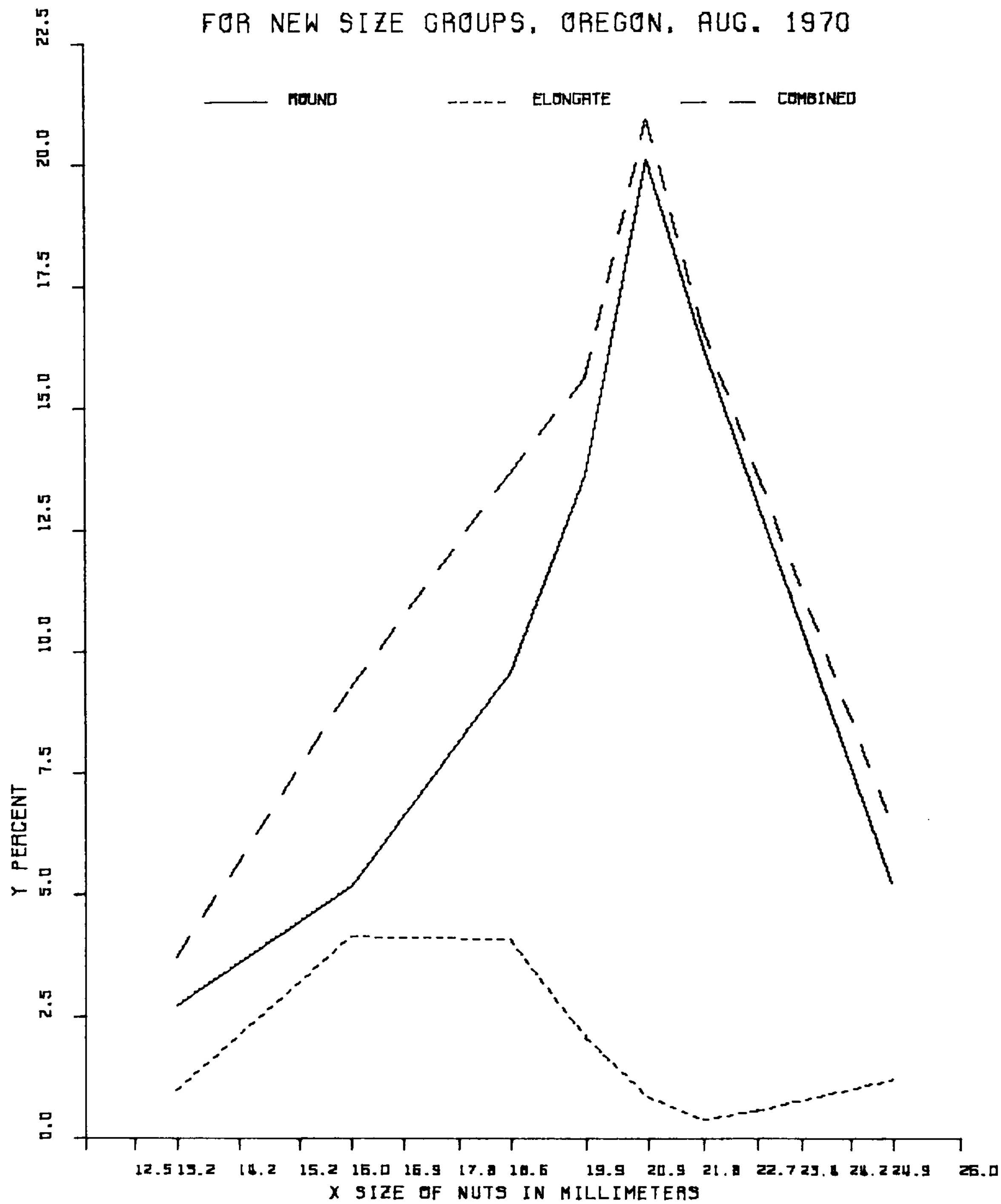
Table 30 shows the old size breakdowns as compared to the new recommended sizes. The round type nuts in the new size group 1 should be discarded for the reasons above but kept for the elongate type nuts.

The new size groups show a small decrease in the variance of the weight per nut for both nut types. The variances under the old size groups were .336 and .950 for the round type nut and elongate type nut, respectively. The variances under the new size groupings are estimated at .327 and .896 which are decreases of 2.7 percent and 5.6 percent. Graph 14 shows the approximate distribution of the nuts under the new size groups recommended.

Table 30.- Old size classifications and recommended new size classifications for filbert objective yield surveys

| Old sizes | | | New sizes | | | |
|---|---|---|---|---|---|---|
| Size code | Medium size | Size break | | Size code | Medium size | Size break |
| | Mm. | Mm. | | | Mm. | Mm. |
| 1 | 12.7 | | | 1 | 13.2 | |
| | | 13.2 | Small | | | 14.2 |
| 2 | 13.7 | | | 2 | 16.1 | |
| | | 14.2 | | | | 17.9 |
| 3 | 14.7 | | Medium | 3 | 18.5 | |
| | | 15.2 | | | | 19.4 |
| 4 | 15.7 | | | 4 | 19.9 | |
| | | 16.2 | | | | 20.4 |
| 5 | 16.7 | | Large | 5 | 20.9 | |
| | | 17.2 | | | | 21.4 |
| 6 | 17.6 | | | 6 | 21.8 | |
| | | 18.0 | | | | 22.2 |
| 7 | 18.4 | | | 7 | 22.7 | |
| | | 18.8 | Jumbo | | | 23.2 |
| 8 | 19.2 | | | 8 | 24.9 | |
| | | 19.6 | | | | |
| 9 | 20.0 | | | | | |
| | | 20.4 | | | | |
| 10 | 20.8 | | | | | |
| | | 21.2 | | | | |
| 11 | 21.7 | | | | | |
| | | 22.2 | | | | |
| 12 | 22.7 | | | | | |
| | | 23.2 | | | | |
| 13 | 23.6 | | | | | |
| | | 24.0 | | | | |
| 14 | 24.4 | | | | | |
| | | 24.8 | | | | |
| 15 | 25.2 | | | | | |
| | | 25.6 | | | | |
| 16 | 26.0 | | | | | |

GRAPH 14. PROJECTED DISTRIBUTION OF NUTS FOR NEW SIZE GROUPS, OREGON, AUG. 1970



## E. Green Size Adjusted to Dry Size

The size of green nuts at the time of the August 1 survey needs to be adjusted to determine size distribution at harvest. This adjustment could be accomplished in one of two ways: (1) Adjust holes in sizing plate to allow for shrink (direct method); (2) combine size data for green nuts and air dry nuts (indirect method).

(1) Direct method - The adjustment needed in the sizing plate was determined using percentages in each of the size groups when dry and green. The following formula was the basis for the adjustment. The first two size groups were left out since no nuts occurred in them in the final harvest.

$$x_i = \frac{P_i - G_i}{g_i} (x_{i+1} - x_i) + x_i$$

Where $P_i$ is accumulated percentages in each size group from 3 through 16 at preharvest.

$G_i$ is accumulated percentages in each size group from 3 through 16 at August 1 (green).

$g_i$ is percentage in each size group at August 1 (green), $i = 3, 4, \ldots, 16$.

$x_i$ is the upper size break for each size group in millimeters.

The results over the 14 size groups showed that an increase in the diameter of the opening was needed at all size groups to determine directly the distribution of nuts when dry. Below are shown the eight size groups recommended earlier along with the new size needed to adjust to dry basis.

| Dry size diameter | Green size for adjusting to dry size |
|---|---|
| Mm. | Mm. |
| 14.2 | 14.6 |
| 17.9 | 18.3 |
| 19.4 | 19.9 |
| 20.4 | 20.9 |
| 21.4 | 22.0 |
| 22.2 | 22.6 |
| 23.2 | 23.6 |

(2) Indirect Method - This method would involve an extra step or two in the laboratory process. The nuts are sized when green to determine the distribution at this time. The nuts would then need to be air dried to about 10 percent moisture and sized again. Then the two distributions are added together to form a new distribution of nuts. This new distribution is very close to the distribution at harvest time. This new distribution is a compromise between the distribution when green and the distribution when air dry (see Graph 15). Graph 16 shows the distribution at harvest time as compared to the compromise distribution obtained by the indirect method.

F. 1971 Production Estimate

The simple direct expansion estimate of weight of good nuts per tree, by terminal limb was used as in the previous year. The sampling errors of the two-stage and three-stage regression estimates were only slightly better than for the direct expansion. Therefore, these were not continued. The weights per good nut used in the 1971 estimate are shown in the section on the "Fall Packers Survey."

A regression estimate for weight per nut and a ratio estimate of production were added in 1971.

1. The regression equation was used to estimate the final weight per nut from the green weight per nut as of the August 1 survey. Identical sample trees in the August 1 survey and the preharvest survey were matched and the weights per nut were regressed against each other. The August green weight per nut was the independent variable while the preharvest weight per nut was used at the dependent variable. The regression equation is

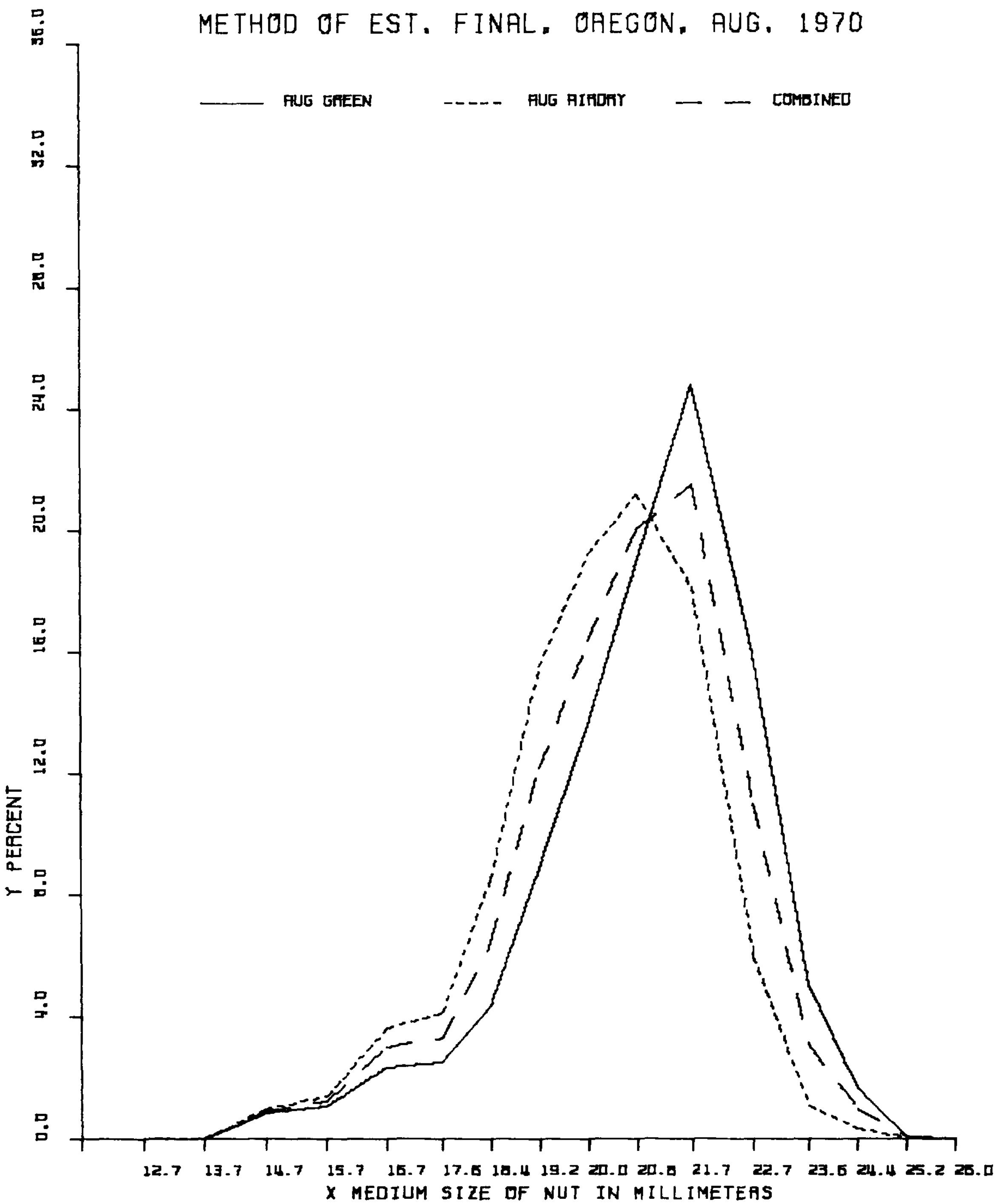
$$Y = .1765 + .72727 X$$

Where Y is the estimated harvest weight per nut

X is the green weight per nut on August 1.

These sets of data were also very highly correlated (correlation coefficient of .99226). These weights per nut were then used in the simple direct expansion estimate in place of the previously determined historic weight per nut.

GRAPH 15. DISTRIBUTION SHOWING INDIRECT METHOD OF EST. FINAL, OREGON, AUG. 1970



2. The ratio estimate of production (YR) was computed as

$$YR = (R)\ (YLAST)$$

where YLAST is the 1970 estimate of production, and

$$R = \sum_{h=1}^{3} w_h \frac{\sum_i Y'_{1(hi)}}{\sum_i Y_{1(h)}}$$

where $w_h$ are proportional to last year's direct expansion estimates for the h strata ($\Sigma w_h = 1$).

$Y'_{1(hi)}$ is the sum of the individual tree $Y'_{1(hij)}$ estimates for the ith block on this year's survey, and

$Y_{1(hi)}$ is the sum of the individual tree $Y_{1(hij)}$ estimates for the same block last year.

GRAPH 16. COMPARISON OF PREHARVEST WITH AUG GREEN PLUS AIR DRY, ORE. AUG. 1970