SOME STUDIES ON THE ESTIMATION OF TOBACCO YIELD

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SUMMARY. This paper presents some results obtained from an experimental survey of acreage and yield under the Virginia Flue Cured variety of tobacco in Guntur (A.P.).

The acreage estimates were obtained with less than 5% error and compare well with the parallel estimates based on primary data returned by the village officials. Ad-hoc estimates obtained by one of the interested agencies for planning their purchase policy were found to be seriously under-estimated.

Apart from an estimation of total yield, the possibilities of predicting total yield of tobacco, which is harvested in a number of intermediate pickings, well ahead of the final reapings, have been explored. It appears that some advantage may be taken of the high correlation between leaf-area with actual yield in a double sampling technique. Besides, suitable technological ratios or regression methods may be adopted on which it will be possible to obtain reasonable estimates of overall yield on the basis of progressive harvests, as soon as several pickings have been made. Some discussions on the different stages of processing, like, curing of leaves and grading of the cured leaves have also been made.

1. Introduction

The Flue Cured variety of Virginia tobacco (FCV), cultivated extensively in southern parts of India constitutes one of the most important cash crops which earns considerable amount of foregn currency. Its price and hence the prospects of its marketing abroad in the face of international competition is controlled by the external demand on the one hand and actual production on the other. Until now, ad-hoc estimates of production are obtained by the interested agencies on the basis of information collected at the village level, sometimes on a 'general feeling', and thus highly subjective. The official statistics regarding either acreage or yield are however available at a much later date, and are hardly of any use for purposes of advance planning.

During the year 1963-64, a pilot study on the problem of estimating the production of tobacco in advance was carried out in a selected centre of district Guntur under the direction of the Madras branch of the Statistical Quality Control Unit (SQC) in collaboration with the Special Studies Unit of the Indian Statistical Institute. The field staff was furnished by the SQC, while planning, designing and technical guidance were contributed by the Special Studies Unit, which also analysed the data.

The main objects of this study were (i) an appraisal of the ad-hoc estimates of acreage under FCV and estimates based on objective methods and (ii) to develop suitable techniques for the prediction of FCV yield, well in advance, before the entire harvesting was completed for the season.

The entire study was planned in two phases (a) an area survey to estimate the acreage under FCV and (b) crop-cutting experiments to get yield rates with special emphasis on the study of auxiliary plant characters associated with yield in each successive reaping.

The results discussed in this report are presented in two separate sections. The estimates of acreage and yield of Flue Cured Virginia for the sampled block are given in Section 3. In Section 4, the results of special studies are discussed suggesting certain technological factors and double sampling techniques for the prediction of tobacco yield in advance.

2. AREA AND YIELD OF FLUE CURED VIRGINIA : PLAN OF INVESTIGATION

Geographical coverage. The study was taken up in a compact block of 256 thousand acres spread over 61 villages of Guntur district in Andhra Pradesh.

Sampling design. A stratified uni-stage sampling design was adopted for acreage survey with clusters of five consecutive survey plots selected with probability proportional to geographical area as the sample units. For crop-cutting experiments a three stage sampling procedure was adopted, where villages selected with probability proportional to FCV area, fields growing FCV tobacco, selected with equal probability and finally an area covering 36-40 plants selected again with equal probability formed the first, second and third stage units respectively.

Stratification and allocation of samples. The block under survey consisted of 4 sections (zones) namely Northern, Western, Southern and Eastern. These were kept intact as primary strata. Within each primary stratum the villages were classified into 2 classes, villages with high proportion of tobacco and villages with low proportion of tobacco. Each class of villages within the primary stratum formed a secondary stratum (sub-stratum). A total of 800 sample units (for area survey) were allotted to the primary strata, 160 each for Western and Nothern zones and 240 each for Southern and Eastern zones. The zonal quota was then allocated to the secondary strata on the basis of $g\sqrt{pq}$ where g is the geographical area of the secondary stratum, p the proportion of FCV and q being $1-p$. For the yield studies 3 sample villages were allotted to each of the primary stratum. From each village 14 fields growing FCV and from each field one unit for crop-cutting experiments were selected.

3. SURVEY FOR THE ACREAGE UNDER FCV CULTIVATION

Selection of plot clusters for area survey. Sample clusters of 5 plots were selected with probability proportional to cluster area, with the help of cadastral survey maps. In Southern and Eastern zones, three sub-samples of 80 sample clusters each were selected while in Northern and Western Zones 2 sub-samples of 80 sample clusters were selected, so as to have independent estimates of area under FCV.

Operational procedure. The selected sample plots were identified with the help of the village Karnam and the sides of each FCV patch were measured in steps by the investigators. These were later converted into area by investigator-specific conversion ratios. The area of FCV as entered in the Karnam's village records was also copied out for all the sample plots after the survey was over.

Proportion of area under FCV cultivations. Proportion of area under Flue Cured Virginia along with their percentage errors are given in Table 1 for each zone separately. An estimate of the proportion of FCV area based on the Karnam's returns is also given for comparison. In col. (8) ad-hoc estimates of the proportion of area under FCV as prepared by one of the important leaf tobacco exporting agencies is also presented.

The proportion of area under FCV cultivation has been estimated as

$$\bar{p} = \frac{1}{\sum_i g_i} \sum_i \frac{g_i}{n_i} \sum_{j=1}^{j=n_i} \frac{a_{ij}}{g_{ij}}$$

where a_{ij} and g_{ij} are the area under FCV and geographical area of the j-th cluster of the i-th sub-stratum and n_i the number of clusters surveyed in the i-th sub-stratum and g_i its geographical area. The standard errors of estimates were obtained as

$$s^2 = \frac{1}{k(k-1)} \sum_{i=1}^{i=k} (p_i - \bar{p})^2$$

where p_i is the estimated proportion under FCV based on i-th sub-sample, and k the number of sub-samples. Similar procedures were dopted for Karnam's area also. It is seen from

TABLE 1. ESTIMATED PROPORTION OF AREA UNDER FCV FOR THE YEAR 1963-64.

zone	number of clusters		estimated proportion of area under FCV				ad-hoc estimate (A)	percent of under-estimation of 'A' against 'S'
	survey	Karnam	survey (S)		Karnam (K)			
			p	percent error	$\bar{p}$	percent error		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Northern	150	136	.274	5.01	.249	5.55	.140	48.9
Eastern	189	173	.311	8.09	.300	6.52	.228	26.6
Sourthern	219	202	.256	8.18	.254	6.71	.208	18.7
Western	141	159	.107	7.23	.118	12.95	.089	16.3
all zones	699	652	.242	4.24	.235	3.72	.175	27.6

cols. (4) and (6) that the estimates based on the Karnam's return did not materially differ from the investigator's observations in respect of sampled plots. It may be noted here that apart from help received in identifying the plots, the investigator's enumeration was completely independent of the Karnam's official records, as the investigator was required to measure the sides of each FCV parcel in terms of his own steps, while the conversion into acres was done at the laboratory.

4. SURVEY FOR THE YIELD OF FCV CULTIVATION

Harvesting of tobacco leaves in multiple reapings. Estimation of tobacco yield is complicated by its pattern of intermittent harvesting at intervals of about a week, total number of such reapings going upto 8, 9 and even 13 in some cases. Crop-cutting experiments for FCV must therefore be so designed, as to enable the investigator to attend each of them at the proper moment, when the grower would choose to pluck them at the successive reapings. Unlike most other crops, total yield of any chosen plot cannot be ascertained by a single crop-cutting experiment. Besides, it is impossible for the investigator to operate on his own, independent of the grower, even if he was permitted to do so. For, the investigator is neither competent to judge if the leaves have matured enough for plucking, nor can be certain, how many reapings preceded his present visit. He is therefore tied down to his chosen fields and must necessarily be accompanied by the grower at the time of reaping. This lack of freedom to choose his own time or to cover an independent sample of fields duly representing the various reapings makes the problem very difficult. It thus appears that an investigator can command only a small area so that he can maintain a direct contact with the grower concerned and synchronise his own activities with him. The number of sample villages for crop-estimation purposes cannot therefore be made very large.

Selection of sample units and operational procedure. Out of the 61 villages, a small sample of villages, 3 in each zone was selected with probability proportional to FCV acreage in 1962-63. In each village 14 fields growing FCV were selected at random from all the FCV growing fields. The ultimate sample unit, an area covering 36-40 plants was selected from each sample field in the following way. The field in question was first divided into halves, judged on the basis of total number of rows. After clearly defining each half, one was selected at random. This process of halving and selcting one at random was continued till an area of 36-40 plants (DBL Unit)* was obtained. This was then very clearly demarcated with pegs and ropes. Each sampling unit, constituted of a bunch of adjoining plants, was split up into four quarters, for one of which, each individual leaf plucked in a reaping was measured and the total length from tip to stalk and its maximum breadth were both recorded correct to the nearest millimetre. Besides, weight of green leaves harvested in each reaping from both the quarter unit as well as the full unit was noted correct to a gramme.

Estimated yield rate. Average all-zone per acre yield of Virginia Tobacco in terms of leaf-weight, green as well as cured in kilogrammes and leaf-area in sq. metres have been given in Table 2 below along with their standard errors. These yield rates, which refer to the flue cured produce and exclude the sun-cured portion are based on the crop-cutting experiments conducted in 168 fields over the 12 villages. The incidence of losses in leaves during the curing process have been ignored in the calculation of cured weight.

Yield rate per acre in individual fields was computed as $\frac{y \times (2)^r}{A}$ where y is the cluster yield, r is the number of successive halvings and A is the area of the field in acres while the overall average of yield per acre has ben calculated as the arithmetic mean of the village means. The standard errors of the yield rates were obtained by pooling the stage variances ignoring the effect of stratification.

TABLE 2. PROGRESSIVE YIELD OF LEAF AREA, GREEN LEAF WEIGHT AND CURED LEAF WEIGHT OF FLUE CURED VIRGINIA TOBACCO PER ACRE, AS HARVESTED UP TO SPECIFIED REAPINGS

number of villages—12 number of fields—168

reapings (upto)	leaf area (in sq. metre) per acre	mean yield in kg./acre of	
		green leaf	cured leaf
(1)	(2)	(3)	(4)
1	960 ± 61	204 ± 18	37 ± 2
2	2203 ± 133	688 ± 41	90 ± 6
3	3535 ± 224	937 ± 66	160 ± 11
4	4759 ± 288	1257 ± 85	208 ± 14
5	5817 ± 328	1530 ± 94	262 ± 16
6	6767 ± 382	1779 ± 100	309 ± 19
7	7408 ± 421	1978 ± 113	349 ± 21
8	8088 ± 444	2131 ± 123	381 ± 22
all	8543 ± 433	2258 ± 123	407 ± 23

*This technique of demarcating sample units was introduced by Professor D. B. Lahiri of Indian Statistical Institute.

Analysis of the stage variances. Table 3 below gives an analysis of variance for green and cured leaves and leaf-area into the two stages, namely, 'between villages' and 'between fields' for all the reapings taken together.

TABLE 3. ANALYSIS OF VARIANCE OF THE ALL-REAPING TOTALS (i) LEAF-AREA IN SQ. METRE PER ACRE (ii) GREEN LEAF-WEIGHT IN KG./ACRE AND (iii) CURED LEAF-WEIGHT IN KG./ACRE

stages	d.f.	true coefficients of variation		
		leaf area (mean = 8543)	green leaf weight (mean = 2258)	cured leaf weight (mean = 407)
(1)	(2)	(3)	(4)	(5)
between villages	11	11.0	14.4	15.5
within fields	156	48.7	45.8	46.4
total	167	(50.0)	(47.9)	(47.4)

Thus with 10 fields per village a sample of 420 villages is capable of estimating the all-reaping yield rate of green leaf-weight within a margin of 1% error.

5. Special studies : progressive prediction of the all-reaping harvest based on successive reapings

Auxiliary plant characters concomitant with yield. It is obvious that obtaining advance estimates of yield rates early in the season, however tentative, would be worthwhile from many a point of view. While the acreage under FCV could be estimated quite early, by carrying out a quick sample survey, as soon as the sowings are completed, one has to wait till the very end of the season for obtaining final estimates of total yield. In the present enquiry, some studies have been attempted for the prediction of the overall yield rates based on information collected from a few of the early reapings and utilising concomitant plant characters closely associated with yield.

As stated earlier, length and breadth of each individual leaf harvested in the various reapings were measured correct to a millimetre. The product of length and breadth in individual leaves, summed over all is a direct function of leaf-surface, which will henceforth be mentioned simply as 'leaf-area'. 'Leaf-area' thus computed is expected to be approximately proportionate to the actual leaf-area, since the leaves are more or less similar in shape. In working out the relations between various auxiliary characters with final yield, the village means have been used and the sample has been considered as an unstratified one.

Technological ratios of the all-reaping harvest to yields obtained in intermediate reapings. Table 4 in cols. (2), (4) and (6) gives the ratios of the all-reaping total of cured leaf-weight to the progressive totals of (i) green leaf-area (ii) green leaf-weight and (iii) cured leaf-weight up to each specified reaping while cols. (3), (5) and (7) give their respective coefficients of variations. The ratios were computed at the village level by pooling over the harvested totals of all the sample fields in each village.

Thus, as soon as harvested leaf-area, green leaf-weight or cured leaf-weight up to any particular reaping is estimated, total cured weight over all the reapings may be predicted by multiplying the same by the appropriate technological ratios given in cols. (2), (4) or (6). It will be noted that the coefficients of variation are small specially, after 3rd or 4th reapings.

TABLE 4. RATIOS OF THE ALL-REAPING TOTAL OF CURED LEAF WEIGHT IN KG. TO THE PROGRESSIVE TOTALS OF (i) GREEN LEAF AREA IN SQ. METRES (ii) GREEN LEAFWEIGHT IN KG. AND (iii) CURED LEAF WEIGHT IN KG. UPTO EACH SPECIFIED REAPING

number of villages—12 number of fields—168

reaping no. (upto)	ratios of the all-reaping total of cured leaf-weight in kg. to the progressive totals of					
	green leaf-area* in sq. metres		green leaf-weight in kg.		cured leaf-weight in kg.	
	mean	c.v.	mean	c.v.	mean	c.v.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	.4373	18.41	1.6844	14.96	11.309	14.82
2	.1887	11.49	.7069	11.21	4.663	13.00
3	.1167	10.84	.4404	9.54	2.761	11.77
4	.0863	9.66	.3233	7.82	1.987	10.45
5	.0705	10.28	.2650	7.60	1.567	8.70
6	.0609	10.38	.2292	7.33	1.327	7.67
7	.0551	10.46	.2056	6.58	1.169	6.37
8	.0507	8.30	.1906	5.31	1.073	4.72
rest	.0478	7.70	.1793	3.65	1.000	—

*one-fourth of the all-reaping total of C.W. in full unit : progressive total of green leaf-area in quarter unit.

These coefficients of variation here represent the variabilities in the first stage, i.e., between village ratios. It seems that technological ratios of the all-reaping yield to that obtained up to the third reaping can be estimated within a margin of about 2% with a sample of 25 villages. The size of sample on which these conclusions are based is however very small and further studies are definitely needed for obtaining firmer results. Thus by an estimation of the harvested leaf-area, harvested green-weight or harvested cured-weight up to the first three or four successive reapings, it should be possible to get a dimensional estimate of the all-reaping yield. It has to be assumed however that the yield behaviour observed during this season will be maintained and will be repeated in the future. This in actual reality can never be guaranteed. Weather conditions and thousand other factors will determine the plant career and affect its growth pattern. Nevertheless, this should serve as a preliminary and tentative forecast to be improved successively, as the harvesting progresses. A severe change in the resultant growth pattern within a short span of time is however not very likely to happen.

Double sampling technique. The prospects of predicting the final yield by double sampling with auxiliary characters correlated with yield, would be worth investigating. As expected, total leaf-area is highly correlated with its own weight. Table 5, in col. (2), gives the correlation coefficient of the all-reaping leaf-weight $\left(\sum_i y_i\right)$ with all-reaping leaf-area $\left(X = \sum_i x_i\right)$ as 0.948 against the last cumulative. Thus, green leaf-area is a very suitable character, on which final yield can be estimated as $\bar{Y} = a + b(\bar{x})$, where $\bar{x}$ is the all-reaping mean of leaf-area based on a large sample while the regression coefficients may be based on a smaller sample for which leaf-weight also was determined. Naturally, the all-reaping leaf-area can be obtained only after all the leaves have matured for reaping. A smaller sample required for actual harvesting would no doubt economise cost, but the prediction is not expected to be very much in advance of the final harvests.

The progressive area of leaves $\left(X_1 = \sum_{1}^{i} x_i\right)$ matured up to any specified reaping, as also their corresponding weights $\left(X_2 = \sum_{1}^{i} y_i\right)$ were both found to have a progressively increasing correlation with the all-reaping overall leaf-weight $(\sum_{i} y_i)$ as will be seen in cols. (2) and (5) of Table 5. This furnishes us with two more auxiliary variates, with the help of which, apart from economising the cost of harvesting operations, final yield can be predicted well in advance at any intermediate reaping. The coefficients of linear regression are also given side by side in each case.

TABLE 5. COEFFICIENTS OF LINEAR REGRESSION OF THE ALL-REAPING LEAF-WEIGHT $\left(\sum_{i} y_i\right)$ ON (i) PROGRESSIVE LEAF-AREA $\left(X_1 = \sum_{1}^{i} x_i\right)$ AND (ii) PROGRESSIVE LEAF-WEIGHT $\left(X_2 = \sum_{1}^{i} y_i\right)$

$\bar{Y}$ = 2258 gms. per acre

'true' variability between village-unit = 14%

'true' variability between fields within villages = 46%

total variability between field-units = 48%

cumulatives up to reaping numbered (i)	regression of all-reaping leaf-weight $\left(\sum_{i} y_i\right)$ in kg. on					
	progressive leaf-area $\left(\sum_{1}^{i} x_i\right) = X_1$ in sq. metre			progressive leaf-weight $\left(\sum_{1}^{i} y_i\right) = X_2$ in kg.		
	r	a	b	r	a	b
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	0.689	914	1.40	0.775	870	5.26
2	.793	628	0.74	.876	713	2.63
3	.854	592	0.47	.897	673	1.69
4	.891	436	0.38	.910	588	1.33
5	.882	321	0.33	.926	387	1.22
6	.879	334	0.28	.942	308	1.10
.	.	.	.	.	.	.
.	.	.	.	.	.	.
all	.948	−57	0.27	1.000	×	×

Whichever of these characters X_1 (including the all-reaping total X in the limit) or X_2 are chosen as the independent variate, provisional estimates of final yield may be worked out by utilising the regression coefficients obtained in an earlier survey. This would conform to Type-2 scheme discussed by Mrs. C. Bose (1943). These estimates may subsequently be revised by adopting new regression coefficients based on the current survey, as soon as all the reapings are over.

The dimensional estimates based on technological ratios discussed in earlier paragraphs also provide a method for prediction, although the error of such estimates cannot be ascertained. The merits of utilising progressive leaf-area as the concomitant character may however be questioned on two grounds, firstly, the measurements of leaf-area is itself a laborious job and then it must be taken in the cultivator's presence who can only point out the leaves that are going to be harvested then or a few days hence. The weighing of leaves harvested in a particular reaping is however direct and straight. Yet, the measurement can be very much simplified by noting down the lengths and breadths as has been attempted here, and it does not require the investigator to visit the cluster-unit at the same date and hour as the cultivator chooses for his reaping. The investigator is therefore less tied up with the variable time-table of the cultivator and thus in a position to cover a larger sample than he could attempt, if harvesting also had to be attended. Besides, this may expedite the prediction by a few days' time, if that is considered important.

Sampling over time. The practice of harvesting tobacco leaves in a number of successive pickings, complicates the yield survey operations. In order to follow up the same set of units through all the stages of reaping, an investigator is unduly tied up with the selected fields, for unlike most other crops, he has to accompany the grower himself precisely on the date and hour which he chooses for his reaping operation. A team of relatively stationary investigators, keeping watch over a small number of fields would thus be needed. This could be largely avoided by sampling over time, i.e., by sampling out of whatever is harvested within small sections of time-period. But the successive pickings are so much staggered in time, from village to village, even from field to field, that a time-subsample is likely to be composed of leaves obtained from various pickings in varying proportions. This will be apparent from Table 6 which gives the time-distribution of successive pickings over calendar weeks.

This heterogeneity in the composition of a time-sample would thus introduce a large amount of sampling error and call for a larger sample size. Although, it might increase the mobility of the investigator to some extent, the task of contacting the grower and synchronising his own movements with that of the grower, would still be pretty difficult.

On the other hand, technological ratios for the prediction of overall yield, which was one of our main objects, could be worked out conveniently from yield harvested progressively in successive reapings. For obtaining the reaping-specific yield with which the all-reaping totals may be directly associated, a common set of units were therefore sampled over all their reapings for purposes of the present investigations.

TABLE 6. DISTRIBUTION OF FIELDS IN THEIR DIFFERENT REAPINGS BY CALENDAR WEEKS

calendar weeks	reaping number												
	1	2	3	4	5	6	7	8	9	10	11	12 and 13	total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
15/12-21/12	9	—	—	—									9
-28/12	29	7	—	—									36
- 4/1	48	35	12	—	—	—							95
-11/1	42	46	33	15	1	—							137
-18/1	32	37	42	32	15	1	—						159
-25/1	6	32	41	42	30	14	1	—	—				166
- 1/2	—	9	30	36	41	32	14	4	1	—			167
- 8/2	1	—	8	30	35	37	32	11	1	1	—		156
-15/2	—	—	—	10	24	35	30	24	12	1	1		137
-22/2	—	—	—	—	15	25	33	34	19	8	1	—	135
-29/2	—	1	—	—	1	14	28	24	25	11	7	1	112
-17/3	—	—	1	—	—	1	13	23	15	5	1	1	60
-14/3	—	—	—	1	—	—	—	10	15	2	—	—	28
-21/3	—	—	—	—	1	—	—	—	3	1	—	—	5
total	167	167	167	166	163	159	151	130	91	29	10	2	1402

6. Sampling for the determination of cured weights

Flue-curing of leaves. The green leaves harvested from the full unit in each reaping were finally attached to the standard "sticks", as they are called, and these sample sticks were then loaded into a barn along with others for flue-curing. The weight of cured leaves was separately recorded for each sample stick. In the normal procedure each stick is made to contain 80-100 leaves, while the sample sticks contained a varying number of leaves, ranging between 14 and 325.

Weighing of cured leaves in small quantities for individual sample units has however led to some uncertainties in the results. After curing, the number of cured leaves were counted up again for each sample unit and in a considerable number of cases, one or more of the leaves initially charged to the barn were found missing. On the other hand, the original number exceeded in 22 sample units. There have obviously been cases of partial mix-up or transfer of leaves from one stick to another, within the barn or outside at a subsequent stage after the sticks were taken out.

Table 7 below gives the p.c. losses of leaves in the stage of curing in col. (2). The gross ratios obtained from the cured weights recorded as such to the weight of green leaves, ignoring the incidence of losses etc. in leaves have been shown in col. (3) while, ratios of cured weights to green weights computed on the basis of only those units which suffered no losses or excesses have been shown in col. (4). It is only natural, that there will be some losses of leaves in the stage of curing. The only question is if the 'sample' sticks suffered any abnormal losses compared to the grower's 'routine' sticks. The behaviour of the grower's sticks could not however be studied. It seems certain however that the true ratios will lie somewhere between the observed ratio of .1705 and .1900 obtainable in an ideal situation where no loss is incurred.

TABLE 7. RATIO OF CURED LEAF-WEIGHT TO WEIGHT OF GREEN LEAVES IN FULL UNITS COMPUTED ON THE BASIS OF (i) ALL SAMPLE UNITS IRRESPECTIVE OF LOSSES (ii) SAMPLE UNIT WHERE NO LOSS HAD OCCURRED

reaping no.	ratio of cured weight to green weight		
	per cent loss of leaves	"gross" based on all sample units	"no loss" ratio based on units where no loss/gain of leaves ocurred
(1)	(2)	(3)	(4)
1	15.0	.1400	.1354
2	8.7	.1614	.1686
3	5.8	.1734	.1805
4	6.2	.1778	.1962
5	5.4	.1922	.2000
6	5.6	.1950	.2113
7	6.2	.2022	.2182
8	6.7	.2017	.2180
rest	9.9	.2049	.2244
total	7.7	.1705	.1900

From these experiences, it appears that a flue-curing for each sample unit individually is prohibitive, both on account of the labour and time involved, as also in its departure from the 'normality' of the routine operations. Small weighment by individual sticks is not only time-consuming but may lead to much breakage and formation of scraps. The possibilities of employing individual barns (whole) as a sampling unit for purposes of curing and even for purposes of yield estimation itself, may therefore be seriously examined.

Sun-dried variety (SCV). As a side study, the effects of sun-curing was observed for some of the sample units at their very last reapings. In the grading of tobacco, the sun-cured variety (SCV) constitutes a separate grade by itself. It was interesting to find out the ratio of the weight of SCV to its original green weight, and how it compares to the corresponding ratio for FCV. Although the quality of these two varieties are quite different, it would be interesting to know if the ratios are more or less similar, in which case,a sun-curing of the sample units could be attempted for estimation purposes, where flue-curing is difficult. Table 8 below gives the comparative ratios obtained from the FCV and SCV units. The number of observations for SCV is too small to give any conclusions, but it may be seen that they do not widely differ.

TABLE 8. RATIO OF CURED WEIGHT TO GREEN WEIGHT FOR FCV AND SCV

reaping number	FCV		SCV	
	n	ratio	n	ratio
(1)	(2)	(3)	(4)	(5)
4	166	.178	1	.307
5	163	.192	2	.196
6	159	.195	2	.192
7	151	.202	7	.182
8	130	.202	13	.168
rest	132	.205	34	.200

Obviously, this requires further studies on a properly designed sample of an adequate size.

7. Grading experiment

After the cured leaves come out of the barn, they are graded into a number of categories. This classification into grades is made on a purely subjective basis, by personal judgements alone and thus is liable to vary from person to person who exercises this visual judgement.

In the present study, each sample unit was subjected to this grading procedure and weights returned under separate grades were recorded. Some scraps are usually formed in the different stages of handling the cured leaf. Maximum care was however taken to keep each sample unit intact, i.e., complete with its own scrap. In spite of this, some mix-up has inevitably occurred between scraps from different sample units. Table 9 gives the percentage composition of total cured weight by their different grades taken over all the sample units, separately for each reaping. It will be found that the percentages for some of the grades, have increasing or decreasing trends as the reapings advance.

TABLE 9. PERCENTAGE COMPOSITION OF FCV TOBACCO OBTAINED FROM EACH REAPING UNDER DIFFERENT GRADES

grades	reaping number									
	1	2	3	4	5	6	7	8	rest	total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
D	14.47	17.33	16.29	15.06	14.62	11.67	7.72	5.02	3.32	12.87
M	9.72	13.59	14.59	15.13	9.84	6.94	3.86	0.80	0.76	9.62
X	16.57	16.20	13.80	15.42	13.16	12.26	12.00	9.01	7.64	13.35
S	16.95	13.76	13.32	12.38	15.92	17.16	18.71	21.29	21.86	16.08
total	57.71	60.88	58.00	58.70	53.54	48.22	42.29	36.12	33.58	51.82
S.D.	1.88	1.02	0.18	0.22	0.06	0.18	—	1.06	1.23	0.55
S_2	22.48	10.60	8.53	8.02	9.33	10.17	15.17	22.83	27.59	13.29
total	24.36	11.68	8.71	8.24	9.39	10.35	15.17	23.89	28.82	13.84
D.F.	4.66	13.16	16.28	16.20	16.13	16.68	13.34	10.36	5.94	13.44
C.F.	4.00	6.93	9.84	11.01	12.37	14.12	16.48	18.93	16.51	11.86
total	9.67	20.09	26.12	27.21	28.50	30.80	29.82	29.29	22.45	25.30
CFO	0.91	1.37	1.83	1.21	1.27	0.79	0.73	0.72	0.20	1.10
DG	0.63	1.47	2.49	1.90	4.31	7.25	9.27	7.10	11.76	4.58
Scrap	3.14	1.92	1.66	1.00	2.30	2.41	2.50	2.79	3.14	2.33
DL	1.54	1.43	0.85	0.30	0.33	0.18	0.15	0.00	0.05	0.59
PL	1.84	1.16	0.34	0.27	0.30	0.00	0.01	0.00	0.00	0.44
total	8.26	7.35	7.17	5.76	8.57	10.63	12.72	10.70	15.15	9.04
G.T.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

It would have been very interesting if an experiment employing a number of graders could be conducted, such that each sample unit could be graded by more than one person, each person examining the sample unit more than once. In a properly designed experiment, this would have brought out useful material for its proper standardisation.

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