PLOT-SIZE IN YIELD SURVEYS

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RECENT communications by Sukhatme[1,2] and Mahalanobis[3] have established the conclusion that sample plots of a small size (25 sq. ft. or less according to Mahalanobis) give biased estimates of yield in sample surveys ; but whereas Sukhatme has shown the bias to persist even with a plot-size of 118 sq. ft., Mahalanobis has expressed the view that it becomes practically negligible for plots of size larger than 40–50 sq. ft. Their results relate to crops grown unevenly by broadcasting the seed or sowing it in irregular lines. I have studied the problem of plot-size in yield surveys on cotton, which is sown by a drill in evenly spaced rows in Central India. The results[4] are summarized here, as they provide for the first time information on this question applicable to drill-sown crops.

Plots of three sizes, 1/20, 1/200 and 1/2,000 acre, were compared. In crops sown in uniformly spaced rows, plot-size is defined by a specified length of a given number of contiguous rows. The plots in the present experiment were marked according to this definition, and since the actual plot-sizes differed slightly from the standard size owing to small variations in row spacing, the plot-yields were reduced to the standard size before analysis. Two plots of each size or six plots in all were laid down at random locations in the field. The experiment was done in twenty-six fields at Indore and in an equal number of fields at Government farms in the Central Provinces. In addition to the yields of the plots, yields of whole fields were accurately measured at the Government farms ; but this was unfortunately not possible at Indore. Average yields of seed cotton per acre estimated from the three plot-sizes were :

Plot size	Yield (lb. per acre) Indore	Central Provinces
120 acre	195·7	322·2
1/200 ,,	197·0	354·9
1/2,000 ,,	221·3	421·8

There was a gradual increase in yield per acre as the plot-size was decreased in the Central Provinces experiment. At Indore also the yield from the smallest plot was larger than the other two. A comparison between different plot-sizes did not, however, reveal significant differences in yield, though the excess of yield estimated from 1/2,000-acre plots over 1/20-acre plots in the Central Provinces was almost twice its standard error. The comparison of yields estimated from sample plots with the yield obtained by harvesting the whole fields in the Central Provinces proved more conclusive, as shown below :

Comparison of plots with whole fields	Difference in yield (lb. per acre)
1/20 acre plot	26·7 ± 26·5
1/200 ,, ,,	59·4 ± 28·1
1/2,000 ,, ,,	126·3 ± 57·6

The yield estimated from 1/20-acre plots agreed quite well with the yield for the whole field, as the difference between the two was no more than its standard error ; but the excess of the yield estimated from the other two plots over the yield from the whole field was greater than twice its standard error and clearly significant. With 1/2,000-acre plots, the over-estimation was as high as 42·7 per cent of true yield.

Thus, not only did the smallest plot size, 1/2,000-acre or 22 sq. ft., give highly biased results, but also there was an indication of bias also with the plot size of 1/200 acre or 218 sq. ft. in the Central Provinces experiment. The latter result would seem to show that even plots of 200 sq. ft. cannot always be relied upon to give unbiased estimates of yield. The second conclusion from this experiment is that although small plots, such as those used by English and American workers for sampling drill-sown crops, may not be open to serious objection for comparative purposes, the possibility that yield estimates derived from such plots are seriously biased needs attention.

1 Sukhatme, P. V., *Nature*, **157**, 630 (1946).
2 Sukhatme, P. V., *Nature*, **158** 345 (1946).
3 Mahalanobis, P. C., *Nature*, **158**, 798 (1946).
4 Panse, V. G., *Curr. Sci.*, **15**, 218 (1946).

FUTURE OF PAINT*

MODERN developments in plastic materials have forced the paint industry to concern itself with an ever-increasing number of film-forming substances—synthetic rubbers, resins and oils ; and researches on pigments have not lagged behind. The electron microscope reveals the shape of particles too small for optical resolution. Pigment particles had been assumed to be spherical ; it transpires, however, that of the pigments commonly used only carbon particles have this shape. The shape of carbon particles is independent of the material from which the pigment is prepared. Carbon smoke is different from other inorganic smokes, which, with the exception of aluminium oxide, yield crystalline particles, and the reason for this difference has not been fully explained. The carbon pigments have another interesting property, namely, that of forming chains, like beads on a string. Such an arrangement may be due to electrostatic charges ; but whatever the cause, the condition probably accounts for the high electrical conductivity of carbon-pigmented paint.

Study of the forces which exist at the interface between pigment and medium has shown that they develop the plasticity of the paint on which its working properties depend, and later determine the manner of film formation and structure. Usually they develop quickly and promote dispersion of the pigment. There are cases, however, which can be regarded as dramatic exceptions ; for example, sparks up to half an inch long accompany the attempted dispersion of titanium dioxide by grinding in tricresyl phosphate under electrically insulated conditions, whereas in the presence of a trace of surface-active material (oleic acid) dispersion proceeds normally without the visible release of energy. When paint fails, that is, cracks and exfoliates, the shrinkage forces overcome the combined forces of cohesion (pigment/medium) and adhesion (film/support). When adhesion is good, the development of other paint defects is delayed.

Research into these matters has been conducted by the optical examination of paint sections. In order to use the electron microscope for examination of paint films it is necessary to prepare a replica of the paint surface on a material sufficiently thin to transmit the electron beam. This is done by taking a negative impression of the surface structure of the paint by the simple process of spreading methyl

* Substance of the Friday Evening Discourse entitled "Whither Paint ?" delivered by Dr. L. A. Jordan at the Royal Institution on March 7.