COMPETITION IN FERTILISER TRIALS

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Summary

The influence of "border effects" on experimental results is discussed and the findings of research workers in Hawaii, Louisiana and Queensland are summarised.

The results of a "long term" fertiliser trial which was harvested in sections to test the influence of "end" and "side" effects on treatment means and responses are presented and discussed.

Side effect, measured by the successive elimination of outer rows, appears to have a marked influence on the "response" to Nitrogen, the reduction in mean yield being greatest for the "no nitrogen" plots.

End effects would appear to vary with treatment and interactions, in particular the N x P, become more pronounced with the elimination of end effects.

The reduction in mean yield associated with the elimination of end effects is quite considerable, ten per cent, but becomes relatively smaller with the increased fertility of the plot.

1. Introduction

One of the main objects of field experiments is the comparison of treatment responses under environmental conditions similar to those experienced in field practice. Thus in each plot area it should be the aim to obtain as nearly as possible the environmental conditions that exist under actual field conditions, and the treatment responses obtained on those plots should reflect the response which one would expect to find under the commercial practice of the experimental findings (Naquin 1932).

Davidson (1962), has shown that, due probably to the larger scale farming operations, farm yields approach experimental yields more closely only in years of low yield, all other conditions being assumed equal. For this reason, therefore, it is necessary to consider experimental results in the light of optimal conditions.

Thus, while treatment means may have limited application, comparisons between treatments should, nevertheless, reflect the relative magnitude of the differences to be expected under field applications of the treatments concerned.

From the experimenters point of view, however, it is necessary to have unbiased estimates of the treatment means in order that unbiased comparisons between treatments can be made and, in this respect, it is essential that "border effects" be taken into account when considering the gross and nett plot sizes.

It is often as a result of faulty plot techniques that expected responses (in some cases quite obvious to the eye) fail to materialise when the time comes to harvest the trial and to compare the effects of treatments in terms of yields.

Naquin (1932) in Hawaii has demonstrated with the aid of photographs the border effect of one variety on another. In almost all cases the more vigorous varieties reduced the 4 row plot of the less vigorous variety to 2 lines. The bias in this case is obvious, the yield being obtained from an effective area one half of the nett area.

Photographs were also used to illustrate the effect of "compensation", that is, the two outer rows (of a 4 line plot) of the more vigorous variety take advantage over the less vigorous adjacent variety and in turn produce a smothering effect on its own two inner rows.

Naquin has also demonstrated how the cane in a "no nitrogen" or "control" plot was affected by the nitrogen from the adjacent "high nitrogen" plot. The "lateral drift" of the fertiliser is noticeable as far in as the third line of the eight line plots, which would imply a nett effective area of two lines.

The effect was as marked for "no phosphate" next to "phosphate", but only to a moderate extent (2 rows) in the case of potash.

In all the sugarcane variety trials conducted by Arceneaux (1939) border competition proved to "have a detectable influence on yield relationships, but the error thus introduced was not found important *except* in comparing varieties of widely different vigor".

Kerr (1939) discussing plot techniques under Queensland conditions concludes "that it is evident that the proximity of a variety of superior vigor results in abnormal growth of the outer row of cane and a depressed yield for the neighbouring row of the less vigorous variety. "(An) additional feature is that the abnormal growth of the continuous lines is reflected also in the next row of the respective plots". That is, there is a further border influence of the first border effect; which is in agreement with the photographs of Naquin (1933).

2. Experimental Results

In the past while plot size has ranged from 12 lines × 121′×4′ 6″ to 4 lines×30′×4′ 6″ for fertiliser trials carried out at both the Experiment Station Farms and co-operators land, no attempt has been made to determine an effective plot size for fertiliser trials under Natal conditions. The large 12 lines×121′ plots have proved both unwieldy and expensive and have invariably precluded replications because of the large area of land taken up by one replication.

On the other hand the small 4 line×30′ plots have, after 2 crops, failed to demonstrate any significant response to nitrogen, and, to quote one experiment, the "control" plots after 5 ratoons yielded as high as those plots which had received as much as 500 lbs. N at each successive stage.

With these results in mind together with the observations of Naquin and the analyses of Kerr, Arceneaux *et al*, it was decided to investigate the drift of nitrogen, in particular, over a six line plot.

The trial selected for the investigation was a "Long term" NPK (2^3) factorial replicated 4 times, which was in its first ratoon of its second cycle. Planted originally in November, 1950 it was ploughed out after the third ratoon in 1958 and replanted, the previous plots being located and subjected to the same treatments in the second cycle as in the first cycle.

The treatments for the second cycle, first ratoon were:

Nitrogen: Nil and 100 lbs. N per acre

Phosphate: Nil and 150 lbs. P205 per acre

Potash: Nil and 150 lbs. K20 per acre

The gross plot of 6 lines×48′×4′ 6″ was harvested as follows:

Six feet were cut off the ends of each line and weighed separately from the centre 36 feet. The weights from the ends and centres of the two middle lines were pooled; the 2 line plot being the minimum plot size under investigation (1/100 acre with ends 1/134 acre without ends).

The plot dimensions and areas are given in Table 1.

Table 1

Nett Plot	Plot Dimensions	Area
A (=Gross)	6 lines×48′×4′ 6″	1/33 acre
B	4 lines×48′×4′ 6″	1/50 acre
C	2 lines×48′×4′ 6″	1/100 acre
D	6 lines×36′×4′ 6″	1/45 acre
E	4 lines×36′×4′ 6″	1/67 acre
F	2 lines×36′×4′ 6″	1/134 acre

The treatment means for each plot size are presented in Table 2.

Table 2

Treatment Means in Tons Cane per acre. (Average of 4 plots.)

Treatment	PLOT SIZE					
	A (=1/33)	B (=1/50)	C (=1/100)	D (=1/45)	E (=1/67)	F (=1/134)
Control	47.36	45.02	43.80	41.47	39.19	38.42
n	62.73	62.51	62.16	56.70	56.02	55.05
p	48.01	44.67	43.46	42.02	38.20	36.60
n p	67.10	66.89	67.55	60.78	60.20	60.38
k	49.11	47.11	45.69	43.41	41.27	39.36
n k	66.00	66.19	66.75	59.78	60.17	60.31
p k	52.40	49.64	48.47	46.41	43.67	42.18
n p k	72.24	71.12	71.35	67.03	65.63	65.64
G.M.	58.12	56.64	56.15	52.20	50.54	49.74
S.E. of single plot yield	±3.65	±3.89	±3.58	±3.61	±3.80	±3.40

From Table 2 it will be seen that the reduction in mean yield for the eight treatments with the decrease in plot size is not constant. This differential decrease in yield is demonstrated in Table 3:

Table 3

Treatment	DIFFERENCE			
	(A-B)=d_1	(B-C)=d_2	(D-E)=d_3	(E-F)=d_4
Control	2.34	1.22	2.28	0.77
n	0.22	0.35	0.68	0.97
p	3.34	1.21	3.82	1.60
n p	0.21	−0.66	0.58	−0.18
k	2.00	1.42	2.14	1.91
n k	−0.19	−0.56	−0.39	−0.14
p k	2.76	1.17	2.74	1.49
n p k	1.12	−0.23	1.40	−0.01
Ave decrease in yield for plots				
1) without n	2.61	1.25	2.75	1.44
with n	0.34	−0.27	0.57	0.16
2) without p	1.09	0.61	1.18	0.88
with p	1.86	0.37	2.14	0.73
3) without k	1.53	0.53	1.84	0.79
with k	1.42	0.45	1.47	0.81

Analysis of the differences d_i (i=1-4) reveals a significant reduction in yield for all non-nitrogen plots; that is, the yields obtained from the 2 line plots without nitrogen are significantly less than their corresponding 4 line plot, which in turn are significantly less than their corresponding 6 line plots.

While the response to nitrogen is of the order of obviousness it is interesting to note the increase in the F- values obtained in an Analysis of Variance of the data from the six plot sizes. These results are summarised in Table 4.

From Table 4 it will be observed that the N x P interaction almost attains significance at the 5 per cent level for the 2 line plot "eliminating end effect" (Plot size F). For the 2 line plot "ignoring end effect", (Plot size C), this interaction was only significant at the 20 per cent level.

Table 4

Variation in F- values obtained in the Analysis of Variance of data from 6 plot sizes

Source of Variation	DF	F- Values					
		Plot A	Plot B	Plot C	Plot D	Plot E	Plot F
*Blocks	7						
Nitrogen (N)	1	190.37	213.21	291.82	193.28	220.00	311.71
Phosphate (P)	1	7.95	4.36	6.05	8.50	4.23	5.89
Potash (K)	1	7.97	7.41	9.16	9.41	10.17	12.58
Nitrogen × Phosphate	1	1.67	1.68	2.23	2.32	2.34	4.03
Other two factor interactions	2	<1	<1	<1	<1	<1	<1
Error Mean Square	18	13.3054	15.1061	12.7883	13.0308	14.4290	11.5374

*Note: The NPK interaction was completely confounded with blocks.
The F- values required for significance are: (5%) 4.41, (1%) 8.28.

Table 5

N × P Interaction tables for two Plot Sizes (Means in T.C.A.)

5. (A) *Plot Size* C (=1/100 acre)

Nitrogen

	(1)	n	Difference
Phosphate: (1)	44.75	64.46	19.71
p	45.96	69.49	23.49
Difference	1.21	4.99	

5. (B) *Plot Size* F (=1/134 acre)

Nitrogen

	(1)	n	Difference
Phosphate: (1)	38.89	57.68	18.79
p	39.39	63.01	23.62
Difference	0.50	5.33	

For the two line plots the average reduction in yield when end effects are eliminated is 6.4 tons or 11 per cent but closer inspection of the data from Tables 5 (A) and 5 (B) reveals that this reduction is not consistent for the treatment means under consideration. These differences expressed as percentages of the mean yields in Table 5 (A) are presented in Table 6.

Table 6

Per cent Reduction in Yield with Elimination of End Effects

Nitrogen

	(1)	n
Phosphate: (1)	13.1	10.5
p	14.3	9.3
Mean Reduction (%)	13.7	9.9

From previous results obtained from this trial together with the results presented in Table 2 it would appear that there is a negative response to the application of phosphate alone, in which case "control" is superior to phosphate. Thus from the trend in per cent reduction in yield illustrated in Table 6, it may be postulated that with increasing levels of nutrition (especially nitrogen) the reduction in yield due to the elimination of end effects becomes relatively smaller.

The eleven per cent reduction in yield brought about by the elimination of end effects illustrates why experimental plot yields are invariably in excess of the yields obtained in practice on large areas of land. Table 6 also illustrated that the possibility of using a "conversion factor" common to all treatments in order to "adjust" experimental results, is rather remote.

To eliminate end effects from all nutrition trials would be a very costly proposition but, by increasing the length of the line for each plot, it may be possible to reduce the proportion of ends to centres, in which case the effect of ends on the estimation of treatment responses and interactions will be negligible and the practice of harvesting the centre two lines (of a 6 line plot) will be justified.

References

Arceneaux, G. *et al* (1939). Proc. I.S.S.C.T. 6th Congress. Page 403.

Davidson, B. (1962). Nature Vol. 194. Page 458.

Kerr, H. W. (1939). Bur. Sug. Exp. Stn.Queensland Tech. Comm. No. 11 (1939).

Naquin, E. E. (1932). Proc. I.S.S.C.T. 4th Congress. Bull. No. 11.

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Mr. Gosnell asked if the yields of the various lines in the plots were easily discernable or whether the results only showed up on harvesting.

Mr. Dicks said that end effects tend to mask the differences between the lines but when viewed from an elevated position the difference between nitrogen and no nitrogen plots was distinctly noticeable to the naked eye.

Dr. Cleasby said the problem of the size of plots was largely answered in the paper and would save a lot of time for agronomists in the future.

Dr. Dick (in the Chair) agreed that the analysis in the paper would save a lot of trouble in the future. Previously the Experiment Station had done a lot of field trials and sometimes been at a loss to explain the rather anomalous results and in particularly to explain to growers the high yields obtained from experimental plots.