Residual Effects from Superphosphate, Basic Slag and Bonemeal on Some Paddy Soils in Lower Burma

BY

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THE large number of fertilizer trials carried out in the past on paddy in Burma have demonstrated the frequent large and paying residual effects which follow dressings of farmyard manure and phosphates. The present paper examines some phosphate residuals, which are well known, but concerning which there seem to be few data for tropical paddy soils. Where such data exist they often cover too short a period to reveal the whole of the long-sustained effects of common phosphatic fertilizers. This appears to be chiefly due to the experiments as a whole soon failing to attain significance when the usual analysis of variance is applied to plot yields year by year. Such experiments are often continued for only two, three or four years and then abandoned because the residual effects have fallen to a level where the experiment as a whole does not attain significance. Residual effects do not come to a sudden stop and they require different statistical treatment from the primary effects resulting from the initial dose of the fertilizer. Under rotational cropping systems assessment of the residuals is seriously complicated, but when, as in Burma rice fields, monoculture is the rule, it is possible to compare yield differences between successive crops. Each succeeding crop on land giving a residual response to a fertilizer shows a decreasing increment over the untreated, apart from anomalous results which may arise from the poorly controlled nature of such measurements, seasonal effects, &c. The efficiency of variance analysis applied to residual effects is considerably lower than when applied to the initial response because of seasonal changes and other uncontrollable variables which are unavoidably introduced with each additional time interval. The " die-away " nature of residuals requires that they be treated by fitting appropriate curves. The potential residual effect of a fertilizer will vary according to the kind and quantity of fertilizer applied to each soil, the kind of crop and the climatic conditions. We have attempted to estimate this residual potential for three forms of phosphate on two Lower Burma soils with paddy as a single monsoon crop grown without rotation.

There were two experiments, at Hmawbi and Myaungmya farms, both in the delta of the Irrawaddy. The soils are acid, recent alluviums, lateritic and under a monsoon rainfall of about 100 inches a year falling mostly between May and October. Analyses of the soils are given in Appendix I but these apply to the farm soils as a whole and not specifically to the experimental plots, though there is no reason to suppose there was any important difference. The fertilizers were applied once, shortly before the first crop was transplanted, at the rate of 50 lb. P_2O_5 per acre. The analysis of the fertilizers is given in Appendix II. The same variety of paddy, the pure line C 14—8, was used at both stations throughout the experiments.

Part of the active constituent of the fertilizer disappears each year from the soil either as that part absorbed by the crop and removed with it or that part lost by leaching, erosion or by becoming permanently unavailable and thus losing its potentiality. However it may be removed or lost, $1 - p$ and p may be taken as representing the fraction of the fertilizer used and/or lost and the fraction left in the soil to be available to future crops either at once or by slow changes. It is assumed (*a*) that the seasonal changes affect the yields of the manured and unmanured plots alike, (*b*) that the increments in yield over the unmanured depend entirely or almost entirely on the intake of the fertilizer by the crop and (*c*) that the potentiality of the fertilizer depends entirely on the proportion left available or to become available. Then if .... p^1, p^2, p^3 ..... p^n are the fractions of the fertilizer left over in the 1st, 2nd, 3rd .... *n*th years, $\frac{p^1}{p^2} + \frac{p^2}{p^3} + \ldots\ldots \frac{p^{n-1}}{p^n} = \frac{I_1}{I_2} + \frac{I_2}{I_3} + \ldots\ldots + \frac{In_1}{I_n}$ = Sum of the increment ratios for n years, where I is the increment over controls in each year of the residual effect. The value of p, the residual coefficient, is then determined. From the calculated residual coefficients a regression is fitted, $Y_I = \bar{y}_I + b(x - \bar{x})$ where Y_I is the yield increment and x the residual potentials p^1, p^2 ..... p^n. Using this method the curves are drawn (Figs 1 to 4).

TABLE I

Observed and Calculated Increases over Controls in lb. of Paddy per Plot. Myaungmya and Hmawbi Farms

(*plots 1/60 acre*)

A. Myaungmya

Residual Year	*Basic slag*		*Bonemeal*		*Superphosphate*	
	Obs.	*Calc.*	*Obs.*	*Calc.*	*Obs.*	*Calc.*
1st	15.3	16.1	22.0	22.3	16.2	18.0
2nd	18.2	14.5	19.7	20.5	15.4	15.0
3rd	8.7	13.0	22.0	18.8	17.7	12.7
4th	12.3	11.8	14.8	17.3	8.1	10.8
5th	11.7	10.8	16.4	15.9	8.5	9.4
Mean	13.44 ± 4.17		18.98 ± 3.24		13.18 ± 4.83	

B. Hmawbi

Residual Year	*Basic slag*		*Bonemeal*		*Superphosphate*	
	Obs.	*Calc.*	*Obs.*	*Calc.*	*Obs.*	*Calc.*
1st	15.0	18.9	10.9	15.0	17.0	18.3
2nd	18.5	14.3	16.0	12.0	14.5	14.0
3rd	17.5	11.3	18.0	11.4	15.6	11.0
4th	7.0	9.3	8.0	10.1	6.0	8.8
5th	4.0	8.1	5.7	9.2	6.3	7.3
Mean	10.40 ± 6.96		11.72 ± 6.61		11.88 ± 4.22	

The observed and calculated yields show that the residual potentiality of the fertilizers depends on the proportion left available, or to become available, in the soil.

Applying the method described it is possible to extend the curves of residual responses to points beyond that of the last residual year, the fifth. This is justified by the fact that, as shown by the observed differences given in Table I, considerable residual effects still remained at the end of the fifth year. The curves in Figs. 1 and 2 show the character of the residual responses from these three fertilizers. It would have been more satisfactory if more data covering a longer period had been available, but that is rarely the case with residual trials in the past.

To express the residual responses by a term which would enable easy comparison to be made between one fertilizer or soil and another and which would embrace in such term the characteristics of the residual response in time, use has been made of the half-life period, by analogy with the method of expressing radioactive decay. A second method of expressing the rate of decline in residual responses is by the time required for the response to fall to an arbitrary level which is considered to be the minimum response which a farmer would recognize or which might be considered as economically important. In the present case, the lowest response considered of practical value has been set at 150 lb. paddy per acre. Table II shows the results in the present experiments of expressing the residuals by these two methods.

TABLE II

Residual effects in terms of number of crops taken in the half-life period and in the time before the increment over the unmanured falls below 150 lb. of Paddy per Acre

Fertilizer	*Myaungmya*		*Hmawbi*	
	No. of Crops in half-life period	*No. of responses above 150 lb. paddy per acre*	*No. of Crops in half-life period*	*No. of responses above 150 lb. paddy per acre*
Bonemeal	9	10	8	7
Superphosphate	5	4	3	4
Basic Slag	8	5	4	5

While the half-life expresses the real persistency of the residual effect the number of crops which can be taken with increases of over 150 lb. of paddy per acre above the unmanured is of greater practical importance. The two expressions are quite distinct, as shown by the cases of basic slag and bonemeal at Myaungmya, where while basic is nearly as persistent as bonemeal and has a half-life only one crop less it is not nearly so profitable because the increment from it falls below 150 lb. after only the fifth crop. Its behaviour at Hmawbi is different. At this farm it has a lower persistency as shown by its short half-life of only four crops, but it is more effective, since it gives five crops with increments of over 150 lb. above the control. The great superiority of bonemeal, both in persistency and degree of response, over the other fertilizers is clear and this superiority is the greater when it is remembered that at the time of these experiments the costs of the fertilizers on a P_2O_5 basis were in the ratio bonemeal : super : basic = $6\frac{1}{2}$: 10 : 18.

Table III shows calculated increases in pounds of paddy per acre for these three fertilizers for the initial and residual years down to increments of 150 lb. per acre above the unmanured.

TABLE III

Calculated Increases of Paddy in lb. per Acre over Unmanured from Dressings of 50 lb. P_2O_5 per acre with three Fertilizers. Increases below 150 lb. per acre omitted

	Myaungmya			*Hmawbi*		
	Basic	*Super*	*Bonemeal*	*Basic*	*Super*	*Bonemeal*
Initial gain (observed)	338	360	458	416	303	501
Calculated residuals—						
1st	242	270	335	358	346	284
2nd	217	226	307	271	265	245
3rd	196	191	282	214	208	215
4th	177	163	260	177	167	192
5th	162	—	239	153	—	175
6th	—	—	220	—	—	161
7th	—	—	203	—	—	151
8th	—	—	188	—	—	—
9th	—	—	174	—	—	—
10th	—	—	161	—	—	—
Total of residuals (150 lb. increases and above)	994	850	2,369	1,173	986	1,423
Total gain lb. of paddy per acre initial plus residuals	1,332	1,210	2,827	1,589	1,289	1,924

In the case of super at Hmawbi, the initial response is below that calculated for the first residual. This is because the residuals are estimates from the formula while the initial responses are observed figures.

That phosphates give good results with payable residuals on the paddy soils of Burma has been known for a long time, but their persistency seems to be greater than had been realised. There may be other data for tropical soils more complete than those we have had to use which would repay re-examination.

It may be noted that in laying down manurial trials the probable long effects of previous phosphatic dressings makes it essential to avoid such fields for long periods, up to 17 years in the case of bonemeal dressings at Hmawbi.

SUMMARY

1. An examination has been made of the residual effects of three phosphatic fertilizers on two Lower Burma paddy soils by a method of fitting curves.

2. The responses are found to persist for a number of years which, when only increases of 150 lb. or more of paddy per acre are considered, may last from four to ten years.

3. By expressing the effect as the half-life period of the fertilizer, comparisons can be made of the variation in persistency between responses from different fertilizers on different soils.

4. On the acidic alluviums of Lower Burma the superiority of bonemeal over super and basic slag was considerable, both in persistency and cost.

REFERENCES

1. Hmawbi Experimental Farm Annual Reports.
2. Myaungmya Experimental Farm Annual Reports.

APPENDIX I

Soil Analyses of Hmawbi and Myaungmya Farms

	Myaungmya	*Hmawbi*
Insoluble residue	72.19	63.87
Soluble silica	—	15.26
Ferric oxide (Fe_2O_3)	4.19	3.63
Alumina (Al_2O_3)	9.74	10.07
Lime (CaO)	0.12	0.29
Magnesia (MgO)	0.46	2.29
Potash (K_2O)	0.27	0.57
Soda (Na_2O)	0.17	0.36
Sulphuric acid (SO_3)	0.12	0.08
Phosphoric acid (P_2O_5)	0.03	0.03
Carbon dioxide (CO_2)	0.11	0.02
Organic matter and combined water	8.07	5.53
Manganese oxide (Mn_3O_4)	0.06	—
Organic carbon	2.234	—
Organic nitrogen	0.171	0.72
Available P_2O_5	0.0024	0.0029
Available K_2O	0.0092	0.0147
pH	5.5	6.1

	Myaungmya	*Hmawbi*
Gravel, stone and fine gravel	—	—
Coarse sand	7.3	3.9
Fine sand	10.0	2.9
Silt	24.0	33.1
Fine silt	40.6	43.5
Clay	14.8	9.1

APPENDIX II

Analyses of Fertilizers used at both Hmawbi and Myaungmya

	Bonemeal	*Super*	*Basic slag*
Moisture	9.79	10.47	0.50
Total P_2O_5	19.45	19.94	14.63
Water soluble P_2O_5	—	18.93	traces
Citrate soluble P_2O_5	—	1.01	12.60
Citrate insoluble P_2O_5	—	—	2.03
Nitrogen	3.52	—	—
$Ca_3 (PO_4)_2$	42.40	—	31.91
Fineness—			
100 mm	6.7%		69.5%
50 mm	21.0%		
10 mm	72.3%		

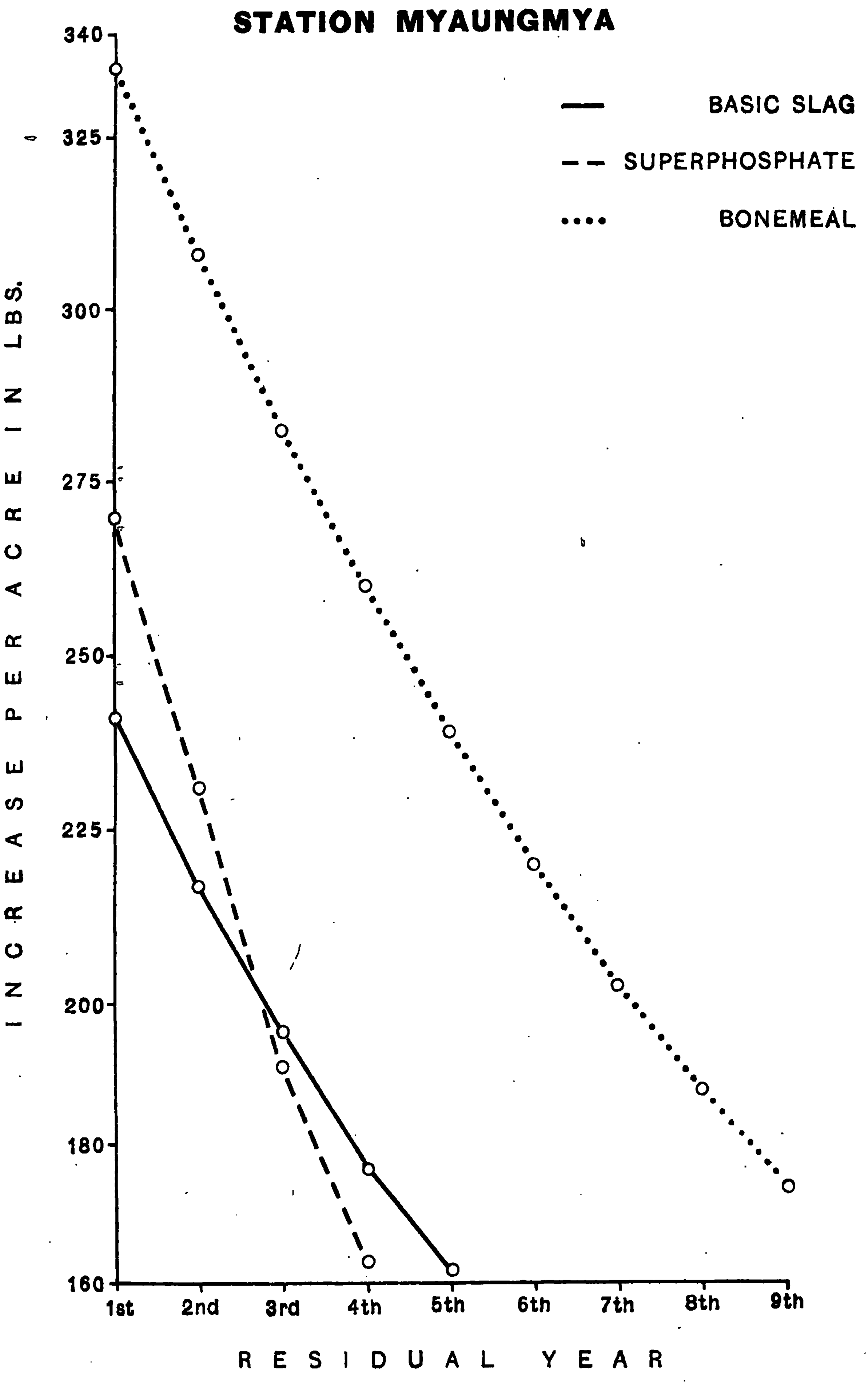

FIG: 1

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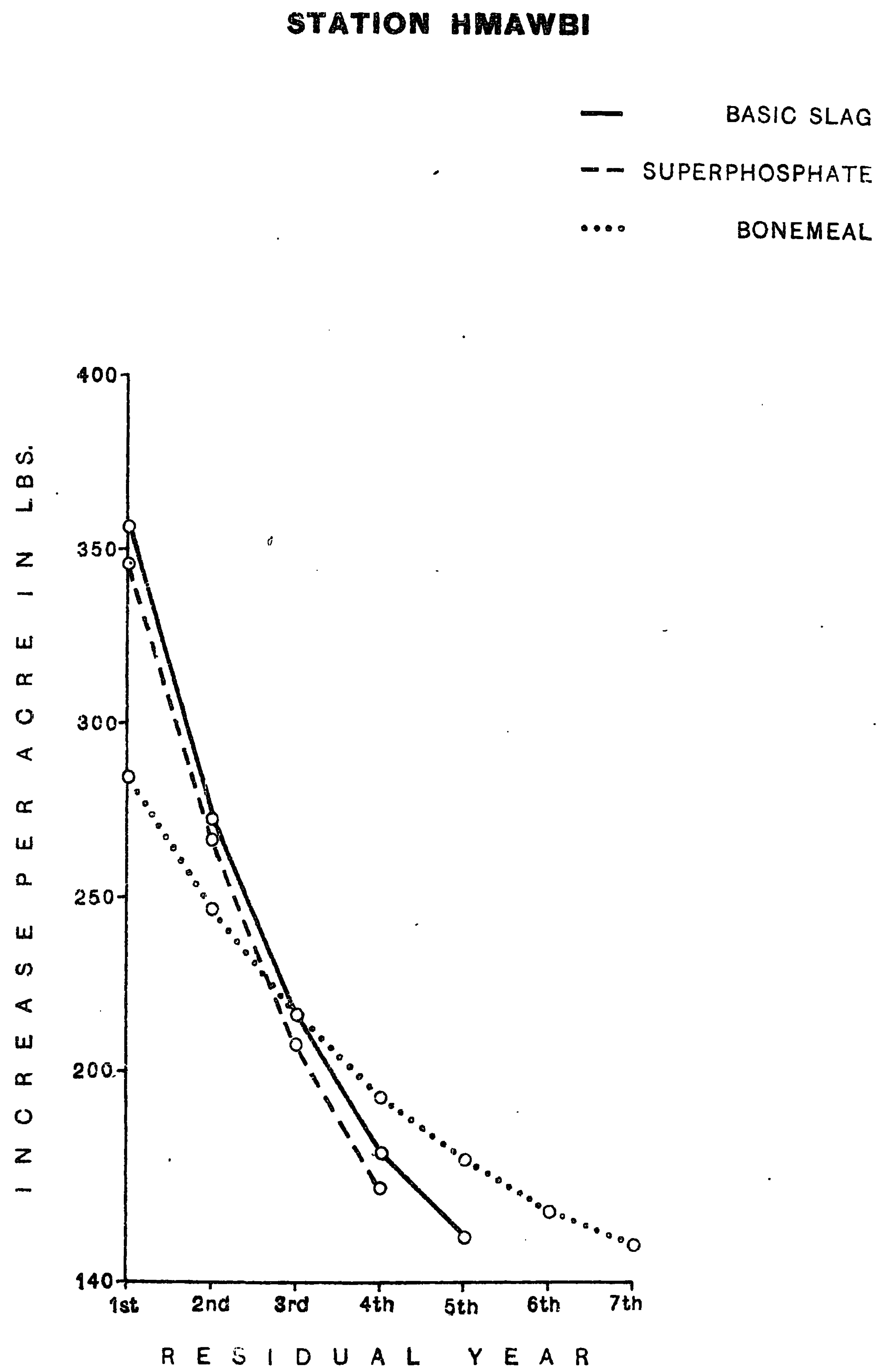

FIG: 2

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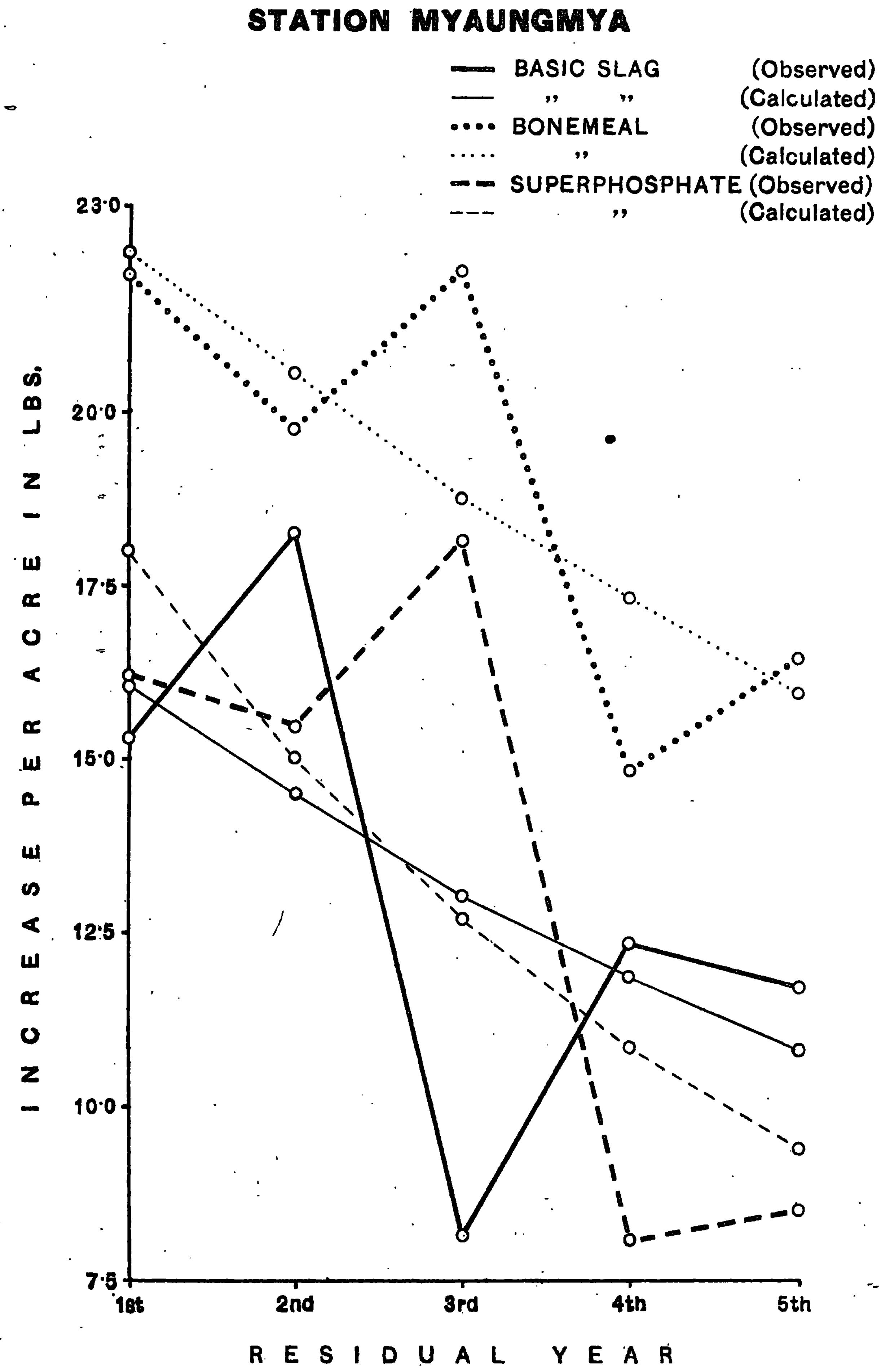

FIG: 3

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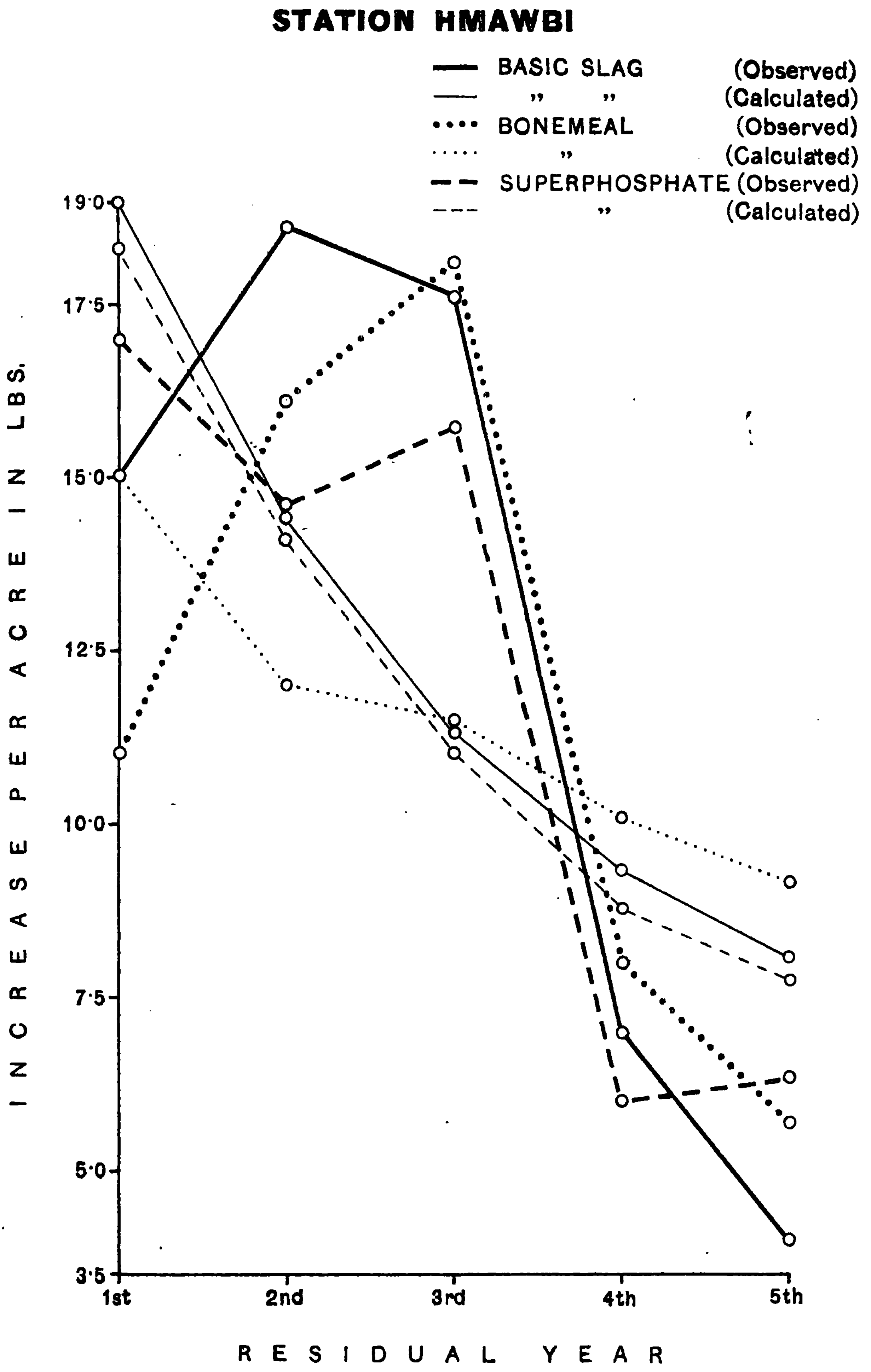

FIG: 4

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