AN EVALUATION OF POULTRY MANURE AS A SUGARCANE FERTILIZER

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Abstract

The findings of a number of experiments designed to test the response of sugarcane to poultry litter are reported. The experiments were conducted with both plant and ratoon crops grown on recent sands and Table Mountain Sandstone (T.M.S.) derived soils. In general, yield responses to poultry litter are no greater than can be obtained from the equivalent N P and K content of mineral fertilizers. It is concluded that organic manures of this type may be satisfactorily used if available on the farm, but to purchase at ruling prices would be economically unsound.

Introduction

In recent years large poultry projects have developed in and around the cane growing areas of Natal. Consequently vast quantities of poultry manure have suddenly become available to the agricultural industry, and interest in this by-product, as a sugarcane fertilizer, has resulted. For this reason a number of experiments have been conducted to evaluate poultry manure. Work was concentrated on those soils where it was considered that a response was most likely to occur. The Recent sands were selected because of their low cation exchange capacity and organic matter content (Beater[2]); the T.M.S. derived soils because of their history of trace element deficiencies and P availability problems (Anon[1]), (Moberly[4]).

Materials

The material used, because of the large quantity available, was manure from broiler houses in which sawdust was used for litter. The manure will be referred to in the text therefore as poultry litter (P.L.). The P.L. used in all cases was unsieved and unmilled. Chemical analyses were carried out on the P.L. on a number of occasions, the results of which are given in Table I.

Experimental

Experiment I: Fernwood sand

The experiment site, at the S.A.S.A.'s Experiment Station farm near Umhlanga Rocks, was relatively unproductive and cane growth was characteristically uneven. The soil analytical data were as follows:

p.p.m.

P	K	Mg	Ca	Na	pH
70	56	43	2 800	33	8,5

P.L. was one of six treatments in a randomised block design with nine replications. The experiment was first established in March 1968 with variety N50/211. All treatments received the same quantities of N, P and K as did the control treatment viz: 165 kg N + 38 kg P + 165 kg K p.ha., but in addition received: (ii) bagasse broadcast at 44 t.p.ha., (iii) filter cake broadcast at 105 t.p.ha., (iv) ferrous sulphate sprayed on the foliage in two applications each of 7 kg p.ha., (v) P.L. applied in the planting furrow at 5,2 t.p.ha., (vi) ethylenedibromide 4,5% (E.D.B.) at 250 l/ha. applied full-cover by hand injector.

Due to inadequate rainfall, poor germination resulted, necessitating the replanting of the experiment. When the old crop had been removed by hand and the furrows re-made, the P.L. and E.D.B. treatments were re-applied. The total quantities applied in treatments (v) and (vi) were, therefore, 10,4 t.p.ha. and 500 l.p.ha. respectively. The replanting of N50/211 was done at the end of August.

Results

The treatments which caused the greatest initial growth response were E.D.B., P.L. and filter cake, particularly with regard to tillering. The Pattern of development of the stalk population is illustrated in Figure 1. E.D.B. also caused quicker stalk elongation than did any other treatment. Of interest was the occurence of iron chlorosis in all except the P.L. and E.D.B. treatments. Iron chlorosis was more

TABLE I

Chemical analysis of five lots of poultry litter used in experiments

	%								p.p.m.			
	H_2O	N	P	K	Ca	Mg	Fe	Al	Cu	Zn	B	Mn
1.	18,4	3,4	1,0	1,2	0,2	0,5	0,1	0,1	20	215	40	320
2.	17,7	3,4	1,0	1,2								
3.	19,1	3,3	1,0	1,2								
4.	17,1	2,8	0,5	1,3								
5.	17,2	2,9	1,3	1,4								

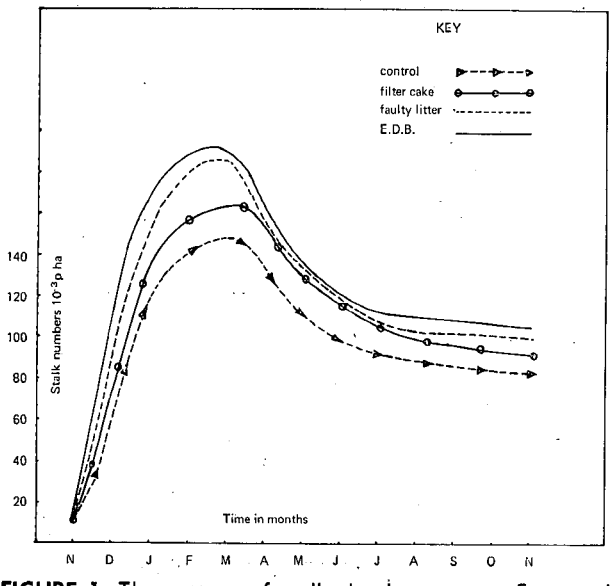

FIGURE 1: The pattern of stalk development on Fernwood sand — experiment 1.

TABLE II

Harvest data from Experiment I on the Fernwood sand

Treatment	t c/ha	ers	t ers/ha	Stalk counts 10^{-3}/ha	kg/stalk
Control	64,2	11,9	7,7	82	0,79
Bagasse	69,9	11,7	8,2	85	0,82
Filter cake	75,1	10,8	8,1	95	0,79
$Fe_2(SO_4)_3$	61,0	12,1	7,2	80	0,70
P.L.	77,6	10,6	8,7	96	0,82
E.D.B.	102,7	10,1	10,4	100	1,04
S.E.	±3,8	±0,26	±0,40		
L.S.D. (0,05)	11,0	0,8	1,1		
(0,01)	14,8	1,0	1,6		
C.V. %	15,0	7,0	14,0		

severe where bagasse had been applied. The plant crop was harvested at 14½ months of age in November 1969, and the harvest data are given in Table II. The response to E.D.B. is highly significant, whilst P.L., although marginally better than the remaining treatments, is only just superior ($P>0,05$) to control in respect of t.c./ha. Third leaf analytical data showed the major nutrients to be adequate for all treatments. The leaf K content was highest in the P.L., filter cake and E.D.B. treatments, being respectively 1,62%, 1,51% and 1,53% compared with the other treatments which averaged 1,33%.

In the first ratoon crop residual treatment responses are being measured, and also the response to top-dressing on the row of P.L. at 5,2 t/ha. superimposed on treatment (iv). Crop measurements in the first ratoon indicate that there will be a positive response to the E.D.B. treatment only; the growth in all other treatments being comparatively poor.

Experiment II: Fernwood sand

On a similar site, adjacent to experiment I, a comparison of two rates and two methods of application of P.L. were made. Using variety N55/805 the experiment was established in August 1968. The treatments were (i) 165 kg K/ha. + 115 kg N/ha., (ii) 4,5 t/ha P.L. applied in the furrow + 83 kg K/ha. to equate the K content with that in treatment (i), (iii) 11,2 t/ha. P.L. applied in the furrow; (iv) 11,2 t/ha. P.L. broadcast and hoed in by hand prior to drawing the furrows.

Results

P.L. caused quicker germination and more tillering. Up to the time of peak population, at the end of February, the stalk populations of treatments (ii) and (iii) were 30% higher than that of the control treatment, but this effect did not persist. The plant crop was harvested at 14½ months of age in November 1969. The harvest data are presented in Table III.

In this experiment, characterised by a high coefficient of variation, there was no statistically significant response to P.L., either applied in the furrow or by broadcasting.

In the first ratoon of this experiment plots were split in treatments (ii), (iii) and (iv) in order to test the response to top-dressing over the row of 4,5 t/ha. of P.L. At present the crop is 16 months old and there is no visible or measureable response to P.L. applied at planting, or applied as a top-dressing on the first ratoon.

TABLE III

Harvest data from Experiment II on the Fernwood sand

Treatment	t c/ha	ers	t ers/ha	Stalk counts 10^{-3}/ha	kg/stalk
Control	82,4	13,8	10,7	105	0,79
P.L. @ 4,5 t+K	73,2	14,5	9,5	105	0,70
P.L. @ 11,2 t in furrow	75,5	13,8	9,3	109	0,69
P.L. @ 11,2 t broadcast	87,6	14,2	11,2	109	0,80
S.E.	±6,6				
L.S.D. (0,05)	20,4				
C.V. %	18,3				

Experiment III: Clansthal sand

The problem of low production on the coarse structureless sands in parts of the Nkwaleni Valley were investigated in a pot experiment in 1969. Cane growth on these sands was generally very poor, but interspersed with small areas of good growth. Soil analysis indicated adequacy of all major nutrients except K, and did not help to explain the differences between the good and poor growth areas. Neither did third leaf analytical data help diagnose the problem, all nutrients being adequate. A typical soil analysis was:

p.p.m.

P	K	Mg	Ca	Na	pH
73	64	190	350	26	6,8

Soil was collected from both the good and the poor growth areas, air dried and 22 kg was placed in each of 25 plastic-lined 25 litre drums.

Treatments

Five treatments were tested and all received 165 kg N/ha. as ammonium sulphate and 220 kg K/ha. as potassium chloride. The treatments were: (i) Control — N and K only, (ii) filter cake at 224 t/ha (55% H_2O) intimately mixed with the soil, (iii) P.L. at 90 t/ha. intimately mixed with the soil, (iv) steam sterilization of soil for two hours, (v) a shotgun treatment of trace elements comprising Zn, Cu, Mo, Fe, B and Mn. For each treatment there were five replications, three of which comprised of soil taken from the poor growth areas and two from the areas of good growth.

The weight of soil at approximately 50% water holding capacity was determined. Water was applied daily when necessary, and once a week the required quantity was added to bring the soil back to approximately 50% water holding capacity.

Five pre-germinated, one-eyed setts of heat-treated NCo 376, all of the same weight, were planted in each pot. Three weeks later the setts were thinned out to four per pot. The nutrients were then applied in solution.

Results

It soon became apparent that P.L. at 90 t/ha. was excessive; growth was extremely slow and in one replication all four stools died. Cane growth in the steam sterilized and filter cake treatments was superior at two months of age, and this persisted through to the time of harvest. At no time was there any apparent difference between the growth of cane in soils from the good and the poor areas. At four months of age third leaf samples were taken from each pot and composited for the good and poor soils. The analytical data are shown in Table IV.

TABLE IV

Third leaf analytical data from Experiment III

		N %	P %	K %	Mg %	Ca %
(i) Control	good soil	2,59	0,25	1,78	0,17	0,47
	poor soil	2,67	0,25	1,74	0,16	0,50
(ii) Filter cake	good soil	2,24	0,28	1,64	0,13	0,44
	poor soil	2,09	0,28	1,56	0,13	0,38
(iii) P.L.	good and poor soil	3,13	0,47	1,95	0,17	0,41
(iv) Steam sterilization	good soil	2,24	0,26	1,83	0,12	0,34
	poor soil	2,75	0,30	2,04	0,15	0,38
(v) Trace Elements	good soil	2,46	0,24	1,64	0,15	0,50
	poor soil	2,74	0,26	1,90	0,16	0,54

TABLE V

Yield data from plant crop in Experiment III

Treatment	Fresh weight (gm)
Control	1 167
Filter cake	1 636
P.L.	866
Steam sterilization	1 412
Trace elements	815

All major nutrients were more than adequate. P.L. caused luxury uptake of N and P in particular.

At 11 months after planting the cane was cut and weighed. The mean fresh weight per pot of all the above-ground tissue from both the "good" and "poor" soils is given in Table V. The mean for the P.L. treatment excludes the replication in which the shoots died.

The response to filter cake and steam sterilization is considerable whilst the trace elements and P.L. have reduced yields due, presumably, to the excessive levels applied.

After harvesting the experiment soil samples from each pot were taken by the Nematology department for assay, the results of which are tabulated in Table VI.

The reduction in numbers of parasitic nematodes due to treatments (ii), (iii) and (iv) is noteworthy.

The ratoon crop was allowed to develop with no further nutrients being applied. Ratoon chlorosis was evident in all except the filter cake and C.L. treatments. The response in the ratoon to the steam sterilization treatment was poor by comparison with the plant crop.

The experiment was terminated when the ratoon crop was 4½ months old and the fresh weight of the above-ground parts are given in Table VII.

The residual response to filter cake has been considerable whilst the response to steam sterilization was recorded in the plant crop only. The highest yield was obtained from the P.L. treatment. This

TABLE VI

Mean Nematode count in 20 ml soil from Experiment III

Treatment	Praty-lenchus	Tylencho-rhynchus	Hoplo-laims	Roty-lenchulus	Tricho-dorus	Dory-laims	Mon-orchs	Sapro-phages
(i) Control	108	12	2	2	0	4	0	140
(ii) Filter cake	3	0	8	0	25*	1	1	81
(iii) P.L.	0	0	0	0	0	1	0	223
(iv) Steam sterilization	16	0	0	0	0	1	3	91
(v) Trace elements	125	30	2	10	0	4	3	247

* Trichodorus were found in one pot only of the filter cake treatment

TABLE VII

Yield data from the ratoon crop of Experiment III

Treatment	Mean fresh weight (g)
Control	298
Filter cake	483
P.L.	536
Steam sterilization	188
Trace elements	300

might be attributable to the level of soil K which was 58, 48, 437, 61 and 65 p.p.m. for treatments (i), (ii) (iii), (iv) and (v) respectively.

Following on the results of the pot experiment, two small field experiments, each with two replications only, were established in the Nkwalini Valley in September 1970. The three soil ameliorants compared were (i) P.L. at 6,5 t/ha., (ii) E.D.B. (4,5%) at 250 l/ha., (iii) filter cake at 100 t/ha. applied in the furrow at planting. At both sites P.L. caused delayed germination, and at six months after planting there is no worthwhile response to P.L., whereas the response to E.D.B. and filter cake, particularly fresh filter cake, is very considerable at one site, and slight at the other.

Experiment IV: T.M.S. Inanda

At Phoenix Wattle Co., Eston, an experiment was established in 1968 to test the response to P.L. applied to a second ratoon crop of variety NCo 376. The chemical analysis of this Inanda soil was as follows:

	p.p.m.				
pH	P	K	Ca	Mg	Na
4,3	20	216	180	39	44

Treatments

The crop had been fertilized, two months after harvest, with 1 120 kg/ha. of fertilizer mixture 4 : 1 : 6(31) (viz. 127, 31, 189 kg/ha N P K respectively). One month later the following treatments were applied: (i) Control: no further treatment, (ii) P.L. at 13,4 t/ha applied in a furrow ± 20 cm deep, drawn in the inter-row and covered with soil, (iii) the equivalent quantities of N P K in 13,4 t/ha of P.L. applied as 1 770 kg/ha ammonium sulphate, 760 kg/ha single super phosphate and 410 kg/ha potassium chloride, applied over the row.

Results

The experiment was cut in May 1970 at 20 months of age and the yield data are presented in Table VIII.

Highly significant responses to P.L. and the high level of fertilizer were obtained. Both components of yield, stalk population and stalk weight, were affected. The results indicate that the P.L. contained nothing that could not be supplied by mineral fertilizers. The results of third leaf analyses, given in Table IX, are interesting particularly because treatment differences became evident only when the cane was relatively old.

At six and seven months old the nutrient levels are seen to be well above the threshold values, but

TABLE VIII

Harvest data from Experiment IV: T.M.S. Inanda

Treatments	t c/ha	ers	t ers/ha	Stalk counts 10^{-3}/ha	kg/stalk
(a) Control	89,1	12,6	11,3	138	0,64
(b) P.L.	114,7	11,5	13,2	160	0,72
(c) Mineral fertilizer	112,9	11,7	13,2	160	0,71
Mean	105,6	11,9	12,6	153	0,69
S.E. Treat. Mean (9 plots)	±4,6	±0,37	±0,70		
L.S.D. (0,05)	14,4	1,2	2,2		
(0,01)	20,6	1,6	3,2		
C.V. %	13,0	9,3	16,8		

at 15 months old both N and P are marginal for the control treatment. The P.L. treatment has caused enhanced uptake of all the major nutrients, but particularly P and Mg. The residual effect of P.L. in the subsequent crop is evident in third leaf

TABLE IX

Third leaf analysis from Experiment IV: T.M.S. Inanda

Age and (sampling date)	Treatment	Nutrient Content % D.M.				
		N	P	K	Mg	Ca
6M (11.2.69)	(i)	2,2	0,22	1,3	0,15	0,33
	(ii)	2,3	0,23	1,4	0,15	0,31
	(iii)	2,3	0,24	1,4	0,14	0,26
7M (17.3.69)	(i)	2,3	0,22	1,7	0,12	0,23
	(ii)	2,5	0,27	1,8	0,14	0,25
	(iii)	2,4	0,23	1,7	0,11	0,24
15M (2.12.69)	(i)	1,8	0,19	1,5	0,16	0,19
	(ii)	2,0	0,24	1,8	0,21	0,22
	(iii)	1,9	0,21	1,7	0,17	0,19

P and Mg content, which at five months old, were 0,26, 0,34, 0,28 and 0,26, 0,31 and 0,25 for treatments (i), (ii) and (iii) respectively. The treatments had a considerable effect on the soil analysis at the termination of the experiment. Soil P and Mg were particularly enhanced by P.L. and Ca also increased but to a lesser degree. These data are presented in Table X.

TABLE X

Soil analytical data at the termination of Experiment IV

Treatment	p.p.m					pH
	P	K	Mg	Ca	Na	
(i)	9	133	32	118	26	4,7
(ii)	58	149	67	269	39	4,8
(iii)	14	156	29	127	25	4,6

Experiment V: T.M.S. Trevanian

In the Upper Tongaat area where soils are predominantly T.M.S. derived, there are some fields

where cane growth tends to be uneven. Good responses to zinc, applied as a foliar spray or to the soil have been obtained in this area. On a site with characteristically uneven growth, an experiment was established in 1966 to test a number of treatments which included filter cake, silica slag, dolomitic lime and zinc sulphate. No response to any treatment was measured in the plant crop. The chemical analysis of this Trevanian series soil was as follows:

p.p.m.

P	K	Mg	Ca	Na	pH
8	101	56	223	33	5,1

In the first ratoon a P.L. treatment was introduced and applied at a rate of 13,5 t/ha over the cane row, on to a trash blanket, and it was not incorporated or covered. As in the case of the other treatments 1 200 kg/ha of fertilizer mixture 4 : 1 : 6(31) was applied in addition.

Results

In this precise experiment (C.V. % 8,5 for t cane/ha) no treatment outyielded the control which received the standard 1 200 kg/ha of 4 : 1 : 6(31) top-dressing. The mean yield over the 24 month period of the crop was 95 t.c./ha indicating that the potential yield for this area had not been obtained, and that P.L. did not contribute anything more than did the mineral fertilizer. Soil analysis after harvest showed that the P.L. treatment enhanced the soil P and K status when compared with control, viz. 15 and 10 p.p.m. P and 117 and 92 p.p.m. K respectively.

Experiment VI: T.M.S. Inanda

In an attempt to determine whether P.L. has a nematicidal effect as well as a nutritional effect, an experiment was established at Umbumbulu in December 1969. The pre-plant soil analysis was as follows:

p.p.m.

P	K	Mg	Ca	Na	pH
7	162	165	300	28	5,3

Treatments

P.L. at a rate of 5,6 t/ha in the furrow was used (i) on its own, (ii) fortified with P and K, (iii) fortified with N P and K and (iv) together with E.D.B. and fortified with N P K.

Results

The experiment has not yet been harvested but the crop growth measurements indicate certain trends. Both E.D.B. and P.L. have improved growth with regard to stalk population and elongation. The response to fortified P.L. is greater than the response to E.D.B. and N P K. The addition of E.D.B. to P.L. and N P K did not enhance cane growth when the crop was 15 months old. The P.L. fortified with N P K has a stalk population and mean stalk height respectively 12% and 19% greater than has the control treatment which received 75 kg N, 70 kg P and 110 kg K per ha.

Third leaf analyses have shown an adequate supply of the major nutrients and only a slight tendency for P.L. to cause luxury uptake of K.

Discussion

Furrow applications of P.L. at planting have increased tillering in the early stages of growth, but cane yields are either unaffected or are increased only slightly. The inconsistency in yield response on the Fernwood sands could possibly be attributed to a differential variety response. The small, but statistically significant ($P>0,05$) response was obtained with variety N50/211, whereas variety N55/805 did not respond to P.L. Similar findings with respect to nematicides have been reported (Dick[3]).

Where a response was obtained on the Fernwood sand, the yield increase was only as good as that obtained from the application of filter cake.

The application of very high rates of P.L. (Experiment III) effectively reduced the number of parasitic nematodes. The adverse effects of such high rates on plant crop yields, as reported in the pot experiment, are unlikely to be as severe under field conditions. High rates of P.L. applied to plant cane should preferably be broadcast, and even at relatively low rates, there is some evidence (Experiment II) that broadcasting and incorporation is preferable to in-furrow placement.

On the Trevanian and Fernwood soils the top-dressing of P.L. on the cane row was not beneficial.

The furrow applications of P.L. to both plant and ratoon crops on Inanda soil (Experiments IV and V) resulted in a positive growth response. However, the data indicate that the same response can be obtained by applying the equivalent rate of nutrients in the form of mineral fertilizers. Organic manures, by virtue of their bulk, are difficult and expensive to apply. The ruling price of P.L. makes its use econoinmically unsound because of the lack of evidence of its being more effective than is the N P K equivalent in the form of mineral fertilizers. One ton of P.L. costs R14,00 and supplies approximately 30 kg N, 10 kg P and 12 kg K, which, when purchased in the form of mineral fertilizer, would cost approximately R9,00.

Conclusions

There is evidence from a number of experiments that the response to P.L. is unlikely to be greater than that which can be expected from the equivalent N P K content in the form of mineral fertilizer. The present price structure therefore, favours strongly the use of mineral fertilizers.

If P.L. is available free to the grower, then it can successfully be used in place of mineral fertilizers, but it should be fortified to meet the full nutrient requirements of the crop. In general, K and perhaps P, will need to be added.

Acknowledgements

The authors wish to record their thanks to the following growers for their co-operation with the field experiments:

Mr. M. H. Byrne, Phoenix Wattle Co., Eston.
Mr. R. C. Cook, Upper Tongaat.
Mr. P. S. Gurney, Umbumbulu.
Mr. R. D. Goble, Nkwalini.
Mr. A. Larsen, Nkwalini.

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Discussion

Mr. Wood: To what do the authors attribute the depressing effect on cane germination with chicken manure application? Could it be that there was sawdust mixed with the manure and this immobilised nitrogen?

Mr. Moberly: I doubt if there was N fixation because the CN ratio of the manure was quite favourable. It is likely though, that the large quantities of N in the form of ammonia will burn the cane setts.

Mr. van der Riet: Chicken manure from other breeders might have a very different composition from the manure that was used.

Mr. Alexander: Chicken manure shows very little variation between sources. It is the amount of sawdust added that alters its effect and also age and storage.

Mr. Sherrard: Would the application of filter cake release phosphate or potash from the Umfolosi alluvial soils?

Mr. Moberly: An application of filter cake seems invariably to cause an increase in uptake of leaf K despite the relatively small amount of K in the filter cake, so it is possible, though certainly there is minimal evidence, that filter cake might influence the release of some soil nutrients.