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On the Manurial Effect of Calcium Cyanamide under Different Conditions.

BY

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Various reports on the efficacy of Calcium cyanamide or lime-nitrogen (Kalkstickstoff) testify in favor of this compound, its action reaching about that of ammonium sulphate or sodium nitrate; other reports again contain a less favorable declaration. Evidently the nature of the soil and the nature of the other manuring compounds used along with it, have a decided influence upon the result.[1] This difference of opinion can not surprise us, since the reports on the comparative efficacy of sodium nitrate and ammonium sulphate differ also very considerably. Under certain conditions, ammonium sulphate was found equal and even superior to sodium nitrate; under other conditions again inferior to this.

The publications on the new manure show among other things, that it can not be used for top-dressing and that it must be applied so ime before sowing, as it would act injuriously before its decomposition by soil-bacteria, liberating its nitrogen as ammonia, is accomplished.

Since however the manurial effect of lime-nitrogen has not yet been compared with those of ammonium sulphate and sodium nitrate under conditions of different reaction of the total manure, it seemed to me of special interest to carry on some experiments along this line. Since lime-nitrogen can be decomposed by various kinds of bacteria into calcium carbonate and ammonia, $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$ it must be defined

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1). Compare especially the publications of B. Schulze, Feilitzen, Roessler, Seelhorst, Strohmer, Stutzer and Aso.

as an alkaline manure, while ammonium sulphate is defined as a physiologically acid nitrogenous manure. Since the ammonia formed by the decomposition of lime-nitrogen will of course rapidly be transformed into carbonate, the question as to which is the best source of nitrogen would be simplified to this: *Under which conditions is ammonium carbonate better than ammonium sulphate or sodium nitrate?*

Kossowitch as well as Prianishnikow have demonstrated recently the injury by too alkaline or too acid reactions. Also here at this stations as well as at the college of agriculture at Komaba near Tokyo similar observations have been made at about the same time. Thus it was observed by myself that ammonium sulphate in conjunction with secondary sodium phosphate produced a much better yield with *Brassica chinensis* than when the former was applied in conjunction with superphosphate. Since lime-nitrogen is an actually alkaline manure, an addition of an acid phosphatic manure would act here favorably—just the opposite from ammonium sulphate.

The sample of lime-nitrogen at my disposal contained 18.58 % N and 56.16 % CaO; the ammonium sulphate[1] = 20.65 % N; the crude potassium sulphate = 47.55 % K_2O; the double superphosphate = 40.42 % P_2O_5 soluble in water; and the secondary sodium phospate was the pure preparation.

I. Experiment with *Hordeum sativum.*

Eighteen porcelain pots (area = 1/200,000 ha.) were filled each with 14.27 kilo. fresh alluvial loam poor in humus, and received the following manures:

A
- 8.752 g. ammonium sulphate
- 4.60 g. double superphosphate
- 3.91 g. potassium sulphate
- 8.44 g. sodium sulphate

B
- 8.752 g. ammonium sulphate
- 9.38 secondary sodium phosphate
- 3.91 g. potassium sulphate

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1). The ammonium sulphate in this experiment was the pure preparation.

C { 10.0 g. lime-nitrogen
4.6 g. double superphosphate
3.91 g. potassium sulphate
8.44 g. sodium sulphate

D { 10.0 g. lime-nitrogen
9.38 g. secondary sodium phosphate
3.91 g. potassium sulphate

Of these four mixtures, A was decidedly acid, D decidedly alkaline, while B and C approached the neutral reaction. Further, in order to provide the pots A and B with as much lime as was contained in the lime-nitrogen, 17.27 g, gypsum were added to these pots on Sept. 7. Gypsum was selected in order not to change chemically the ammonium sulphate; and in order to observe here at the same time the difference in action between gypsum and limestone, two other pots A′ and B′ were prepared in which the equivalent amount of powdered limestone was added on Sept. 7. By this addition, perhaps a little of ammonium sulphate was gradually transformed into ammonium carbonate, the same product which also would be the active principle in the pots C and D. While ammonium carbonate in high dilution is probably more favorable than ammonium sulphate, some loss of this compound by volatilization may take place from soils of little absorptive power, so that the benefit produced in one respect may be frustrated by a disadvantage in another. The following table shows the manuring data, g:

Manure.	A	A′	B	B′	C	D
Ammonium sulphate	8.752	ditto	ditto	ditto	——	——
Lime-nitrogen	——	——	——	——	10.0	ditto
Double superphosphate	4.60	ditto	——	——	4.60	——
Secondary sodium phosphate...	——	——	9.38	ditto	——	9.38
Potassium sulphate...	3.91	ditto	ditto	ditto	ditto	ditto
Sodium sulphate	8.44	ditto	——	——	8.44	——
Gypsum	17.27	——	17.27	——	——	——
Lime-stone	——	10.03	——	10.03	——	——

On Nov. 13, 1905, lime-nitrogen was applied. The pots were kept in a warm house and well moistened in order to accelerate the decomposition of lime-nitrogen. After a week, the other manures were applied. Hence each pot contained 1.858 g N, 1.858 g P_2O_5, 1.859 g K_2O, 1.626 g Na_2O, and 5.618 g CaO.

On Nov. 21, twenty seeds of sixsided barley were sown per pot. After three weeks, the young plants were reduced to 15 per pot of about equal size. The following table shows the height of the plants and number of stalks at two different periods; and the photograph (Plate XXIV, Fig. 1) the development on May 15.

Average of three parallel pots.

N-Manure.	Group.	Jan. 17.		May 24.	
		Height (Cm.).	No. of stalks.	Height (Cm.)	No. of stalks.
$(NH_4)_2SO_4$	A	13.7	32	97.3	53
	A'	14.2	30	104.8	53
	B	13.9	32	98.2	51
	B'	12.4	26	99.7	50
$CaCN_2$	C	13.9	39	102.4	50
	D	13.3	31	98.5	50

The plants were harvested June 3:

Harvest, average of three parallel pots; air-dry, g.

N-Manure.	Group.	Grains.	Straw.	Chaffs.	Total.	Comparative yield total.
$(NH_4)_2SO_4$	A	62.40	79.63	4.83	146.86	107
	A'	48.20	87.00	6.50	141.70	103
	B	58.77	84.57	5.20	148.54	108
	B'	51.53	86.67	4.60	142.80	104
$CaCN_2$	C	56.00	87.40	4.85	148.25	108
	D	48.50	83.73	5.30	137.53	100

It is therefore clear that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words, *the neutral mixture (C) was better than the alkaline mixture (D).* The manuring effect of lime-nitrogen in C was here equal to that of ammonium sulphate in B, when this was applied in conjunction with sodium phosphate.

II. Experiment with *Brassica Chinensis.*

The soil was an alluvial loam, almost free of humus. Eighteen porcelain pots (area = 1/200,000 ha.) were filled each with 14.27 kilo. of the fresh soil, and manured[1] as follows, g:

Manure.	A	A′	B	B′	C	D
Ammonium sulphate	12.0	ditto.	ditto.	ditto.	——	——
Lime-nitrogen...	——	——	——	——	13.34	ditto.
Double superphosphate	2.2	ditto.	——	——	2.2	——
Secondary sodium phosphate...	——	——	4.5	ditto.	——	4.5
Potassium sulphate...	5.2	ditto.	ditto.	ditto.	ditto.	ditto.
Sodium sulphate	4.05	ditto.	——	——	4.05	——
Gypsum	23.03	——	23.03	——	——	——
Lime-stone	——	13.38	——	13 38	——	——

Each pot contained therefore 2.478 g. N, 0.89 g. P_2O_5, 2.473 g. K_2O, 0.78 g. Na_2O, and 7.493 g. CaO.

Twenty seeds of *Brassica chinensis* were sown per pot Sept. 29. After two weeks, the plants were reduced to seven per pot of about equal size. The length and number of leaves on Nov. 7 were as follows:

1). To the corresponding pots, the lime-nitrogen, gypsum, and lime-stone were applied Sept. 7, the phosphatic manures a week later, and the other manures were applied still a week later, in solution.

Average of three parallel pots.

N-Manure.	Group.	Length (cm.).	No. of leaves.
$(NH_4)_2SO_4$	A	23.3	61
	A′	20.7	58
	B	22.1	57
	B′	22 5	57
$CaCN_2$	C	23.9	56
	D	21.8	56

The adjoining Plate XXIV, Fig. 2 shows the state of development at that time.

The plants were harvested Nov. 13 with the following result, g.:

Average of three parallel pots.

N-Manure.	Group.	Fresh state.			Air-dry state.		
		Leaves.	Roots.	Total.	Leaves.	Roots.	Total.
$(NA_4)_2SO_4$	A	169.2	9.0	178.2	18.2	1.3	19.5
	A′	156.3	8.2	164.5	17.7	1.1	18.8
	B	182.8	10.2	193.0	20.2	1.4	21.6
	B′	173.3	8.8	182.1	19.1	1.2	20.3
$CaCN_2$	C	177.4	11.7	189.1	19.7	1.5	21.2
	D	155.6	10.5	166.1	17.4	1.3	18.7

If we now assume the total yield (in the air-dry state) of the pots D to be = 100, we obtain the following ratio:

N-Manure.	Group.	Comparative yield.
$(NH_4)_2SO_4$	A	104
	A′	101
	B	116
	B′	109
$CaCN_2$	C	113
	D	100

The result shows that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words: *the neutral mixture (C) was better than the alkaline mixture (D).* The physiologically acid ammonium sulphate acted however better with sodium phosphate (B) than with superphosphate (A); also this result leads to the inference : *the neutral reaction of the total manure in B* was more favorable than the *acidic reaction in A.*

The moderate dose of calcium carbonate in A′ and B′ was of no special effect in connection with the ammonium sulphate, but this can be easily understood, because the soil contained already some carbonate of lime.

III. Second Experiment with *Brassica Chinensis.*

The amount of nitrogen was here diminished to one third of that in the preceding experiment, and two different kinds of soils[1] i.e. diluvial loamy and alluvial sandy soils served for the test. Forty eight zinc pots (area= 1/200,000 ha.) were filled with the respective soils (15.75 kilo. per pot). Twelve series were prepared, each consisting of four pots. To the respective pots, the following manures were applied, g :

1). The loamy soil from the upland of our station is very rich in humus, while the sandy soil from the paddy field of Kawaguchi near Tokyo is almost free from organic matter.

Manure.	A	A′	B	B′	C	D
Ammonium sulphate	4.0	ditto.	ditto.	ditto.	——	——
Lime-nitrogen	——	——	——	——	4.45	ditto.
Double superphosphate	2.2	ditto.	——	——	2.2	——
Secondary sodium phosphate...	——	——	4.5	4.5	——	4.5
Potassium sulphate...	4.0	ditto.	ditto.	ditto.	ditto.	ditto.
Sodium sulphate	4.05	ditto.	——	——	4.05	——
Gypsum	7.68	——	7.68	——	——	——
Lime-stone	——	4.46	——	4.46	——	——

On December 25, lime-nitrogen was applied, while four months later the other manuring ingredients. Hence each pot contained 0.83 g. N, 0.89 g. P_2O_5, 1.90 g. K_2O, 0.78 g. Na_2O and 2.50 g. CaO. On April 11, twenty seeds of *Brassica Chinensis* were sown per pot. The young plants appeared five days later in all pots with the loamy soil, while the germination in all pots with the sandy soil commenced two days later. On April 25, the young plants were thinned to eight of about equal size.

During vegetation, the plants of the pots B in both series seemed most luxuriant. The following table shows the average length of leaves. measured on May 21 :

Averaged of four parallel pots.

Soil.	N-Manure	Group.	Length (cm.).
L amy soil	$(NH_4)_2SO_4$	A	26.1
		A′	25.2
		B	28.8
		B′	27.9
	$CaCN_2$	C	25.2
		D	26.1

Soil.	N-manure.	Group.	Length (cm.).
Sandy soil	$(NH_4)_2SO_4$	A	28.2
		A′	27.0
		B	27.6
		B′	27.3
	$CaCN_2$	C	22.7
		D	21.5

The plants were harvested May 21 with the following result, g.:

Average of four parallel pots.

Soil.	N-manure.	Group.	Fresh state.			Air-dry state.		
			Leaves.	Roots.	Total.	Leaves.	Roots.	Total.
Loamy soil	$(NH_4)_2SO_4$	A	192.06	11.90	203.96	22.98	1.50	24.48
		A′	188.55	12.20	200.75	22.53	1.35	23.88
		B	217.38	14.25	231.63	24.33	1.53	25.86
		B′	210.17	12.93	223.10	22 57	1.53	24.10
	$CaCN_2$	C	165.79	14.40	180.19	19.07	1.60	20.67
		D	159.89	14.07	173.96	18.13	1.77	19.90
Sandy soil	$(NH_4)_2SO_4$	A	186.60	13.38	199.98	17.80	1.30	19.10
		A′	176.44	10.50	186.94	17.90	0.98	18.88
		B	189.65	12.83	202.48	18.75	1.25	20.00[1)]
		B′	178.66	12.23	190.89	18.65	1.25	19.90
	$CaCN_2$	C	113.25	13.50	126.75	12.37	1.37	13.74
		D	113.71	10.90	124.61	12.35	1.10	13.45

1). With sandy soil the maximum harvest was obtained from the pots B. In the pots B, the average weight of one plant was 2.5 g. (20/8=2.5) and average yield from one kilo. soil amounted to 1.27 g. (20/15.75=1,27), while one plant of the corresponding pots in the preceding experiment with a large supply of nitrogen amounted to 3.1 g. (21.6/7=3.1) and one kilo. soil produced 1.51 g. (21.6/14.27=1.51).

If we now assume the total yield (in the air-dry state) of the pots D in each case of soil respectively to be = 100, we obtain the following ratio:

Soil.	N-manure.	Group.	Comparative yield.
Loamy soil	$(NH_4)_2SO_4$	A	123
		A'	120
		B	130
		B'	121
	$CaCN_2$	C	104
		D	100
Sand soil	$(NH_4)_2SO_4$	A	142
		A'	140
		B	149
		B'	148
	$CaCN_2$	C	102
		D	100

The manurial effect of lime-nitrogen, was in this case, with a small dose of nitrogen, far smaller than that of ammonium sulphate. This difference of the manurial effects between lime-nitrogen and ammonium sulphate was further much larger in the case of sandy soil than in the case of loamy soil. In the case of loamy soil, if we assume the comparative yield from the group B (130) to be = 100, and compare the respective yield from the group C (104), we obtain the following ratio:

Ammonium sulphate.	Lime-nitrogen.
100	80

The comparative yields in the case of sandy soil would be:

Ammonium sulphate.	Lime-nitrogen.
100	69

IV. General Conclusion.

1). The manurial effect of lime-nitrogen varies greatly with the reaction of the other manuring compounds: it acts best when the total reaction in the soil approaches neutrality.

2). The manurial effect of ammonium sulphate varies also greatly with the reaction of the other manuring compounds: it acts better when sodium phosphate than when superphosphate is applied along with it. Also from this fact, it must be inferred that ammonium sulphate acts best when the reaction of the total manure approaches neutrality.

3). The manurial effect of lime-nitrogen is under favorable conditions equal (see barley experiment) to that of ammonium sulphate; but when the nitrogenous manures are compared in small applications, ammonium sulphate proved superior. This result may be due to the changed state of the reaction.

4). On sandy soil, the action of lime-nitrogen was farther below that of ammonium sulphate than on loamy soil.

EXPLANATION OF PLATE XXIV.

Fig. 1.

A_3 Manured with 8.752 g. ammonium sulphate, 4.6 g. double superphosphate, 3.91 g. potassium sulphate, 8.44 g. sodium sulphate, and 17.27 g. gypsum.

A'_2 Manured like A_3, but gypsum was here substituted by 10.03 g. limestone meal.

B_3 Manured with 8.752 g ammonium sulphate, 9.38 g. secondary sodium phosphate, 3.91 g. potassium sulphate and 17.27 g. gypsum.

B'_2 Manured like B_3, but gypsum was here replaced by 10.03 g. limestone meal.

C_1 Manured with 10 g. lime-nitrogen, 4.6 g. double superphosphate, 3.91 g. potassium sulphate and 8.44 g. sodium sulphate.

D_3 Manured with 10 g. lime-nitrogen, 9.38 g. secondary sodium phosphate and 3.91 g. potassium sulphate.

Fig. 2

A_1 Manured with 12 g. ammonium sulphate, 2.2 g. double superphosphate, 5.2 g. potassium sulphate, 4.05 g. sodium sulphate, and 23.03 g. gypsum.

A'_2 Manured like A_1, but gypsum was here replaced by 13.38 g. limestone meal.

B_1 Manured with 12 g. ammonium sulphate, 4.5 g. secondary sodium phosphate, 5.2 g. potassium sulphate, and 23.03 g. gypsum.

B'_3 Manured like B_1, but gypsum was here substituted by 13.38 g. limestone meal.

C_2 Manured with 13.34 g. lime-nitrogen, 2.2 g. double superphosphate, 5.2 g. potassium sulphate and 4.05 g. sodium sulphate.

D_1 Manured with 13.34 g. lime-nitrogen, 4.5 g. secondary sodium phosphate and 5.2 g. potassium sulphate.

(1)

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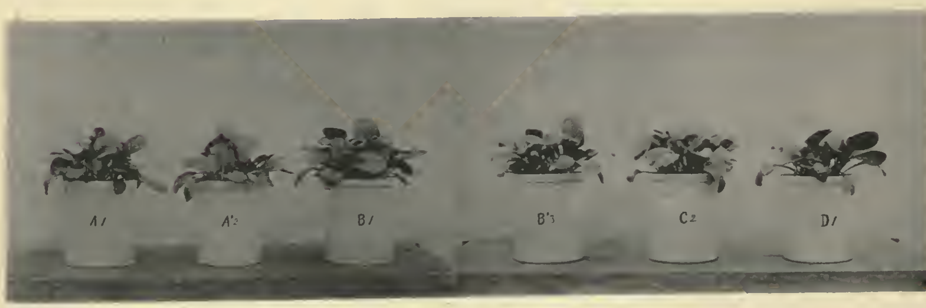
(2)



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