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P.E. Brown
Iowa State College

F. H. Mendell
Iowa State College

SOME BIOLOGICAL EFFECTS OF CERTAIN NITROGEN FERTILIZERS [1]

P. E. BROWN AND F. H. MENDELL

Numerous investigations in the past have shown that nitrogen fertilizers may exert a rather pronounced stimulative effect upon certain biological soil processes. The results of such a stimulation may prove distinctly beneficial to crop growth and the effects of the treatment may, therefore, be of economic significance.

It is recognized, of course, that nitrogenous fertilizers are of value when added to soils, chiefly because of the plant food which they contain.

Often the beneficial effects are much greater, however, than can be attributed to the plant food nitrogen. The secondary, or stimulative effects of the fertilizers may be of considerable significance. The processes of ammonification, nitrification and nitrogen-fixation may be enhanced and beneficial crop effects may be the result. Other biological processes may also be stimulated and the fertility or crop-producing power of the soil increased. Indeed, it is possible that the secondary effects of fertilizers may be more important in some cases than the effect of the plant food addition.

The results given here were secured in a study of the effects of certain nitrogen fertilizers on nitrification in Carrington loam, one of the extensive soil types developed in Iowa.

EXPERIMENTAL

A series of plots 14 by 155 feet was laid out on the Agronomy Farm of the Iowa Agricultural Experiment Station and sodium nitrate, ammonium sulfate, urea, leunasaltpeter and nitrophoska were applied each in three different amounts. The sodium nitrate was added at the rate of 75, 100 and 200 pounds per acre and the other materials were added in amounts which would supply the same quantity of nitrogen as contained in the applications of the sodium nitrate. The sodium nitrate contained 15.24 per cent nitrogen, the ammonium sulfate, 20.38 per cent, the urea, 46.08 per cent, the leunasaltpeter 27.32 per cent and the nitrophoska, 16.50 per

[1] (Contribution from the Laboratory of Soil Chemistry and Bacteriology Iowa State College.)

cent. The treatments were made in the spring prior to corn planting.

The Nitrification Tests — Samples of soil were drawn on June 15, July 6, July 20 and August 24 and the nitrifying power of the soils was determined.

Equivalents of 100 grams of dry soil were weighed out in tumblers in duplicate for three series of tests.

In the first series (A) the soil alone was used to measure the nitrification of the soils' own nitrogen. In the second (B) 30 mgs. of nitrogen were added as ammonium sulfate to each tumbler. In the third series (C) 30 mgs. of nitrogen as ammonium sulfate plus 210 mgs. of $CaCO_3$ were added to each tumbler, the amount of $CaCO_3$ used being theoretically sufficient to neutralize all the acidity developed from the nitrification of the ammonium sulfate.

The moisture content of the soils was adjusted to the optimum and the tumblers were covered and incubated for 28 days at room temperature. The moisture content of the samples was maintained by adding distilled water by weight at regular intervals. All data given are the averages of duplicate determinations.

The First Sampling — The results secured on the samples taken on June 6 are given in table I.

Examining the data in the table it appears that there is no great effect of the nitrogen fertilizers on the nitrifying power of

Table I — Nitrification in the Soils on June 15 p. p. m. Nitrate Nitrogen

Plot No.	Treatment	NO_3N in Soil	Nitrification		
			Soil Alone (A)	Soil + 30 Mgs. $(NH_4)_2SO_4$ (B)	Soil + 30 Mgs. $(NH_4)_2$ SO_4 + 210 Mgs. $CaCO_3$ (C)
7001	Check	11.8	24.5	183.0	332.0
7002	$NaNO_3$ – 75 lbs.	12.6	21.9	228.0	293.0
7003	$(NH_4)_2SO_4$	13.4	26.6	168.0	319.0
7004	Urea	17.0	24.2	163.0	271.0
7005	Leunasaltpeter	13.2	24.0	265.0	254.0
7006	Nitrophoska	14.4	28.7	174.8	272.0
7007	Check	13.4	25.7	150.0	353.0
7008	$NaNO_3$ – 100 lbs.	21.6	34.2	134.0	286.0
7009	$(NH_4)_2SO_4$	25.2	35.6	139.0	291.0
7010	Urea	19.8	31.0	143.0	255.0
7011	Leunasaltpeter	23.6	36.7	114.0	281.0
7012	Nitrophoska	31.0	34.5	136.0	297.0
7013	Check	19.0	37.1	146.0	304.0
7014	$NaNO_3$ – 200 lbs.	18.8	31.8	156.0	261.0
7015	$(NH_4)_2SO_4$	18.6	25.9	144.0	268.0
7016	Urea	31.6	31.1	139.0	271.0
7017	Leunasaltpeter	20.2	34.2	123.0	303.0
7018	Nitrophoska	23.0	35.4	144.0	286.0
7019	Check	17.6	30.2	140.0	245.0

the soil when tested in the soil alone. With the smallest additions of nitrogen the nitrophoska and the ammonium sulfate stimulated the nitrifying power slightly, sodium nitrate depressed it and the other materials had no effect.

With the second addition (100 pounds $NaNO_3$) all the treatments stimulated nitrification, the urea showing the smallest effect and the other materials giving about the same results.

With the largest addition of the fertilizers, none of the treatments increased the nitrifying power to an appreciable extent. The ammonium sulfate on the other hand depressed the nitrification very definitely. The sodium nitrate and urea gave small depressions but they were not significant.

Considering the nitrification as tested by the use of ammonium sulfate, with the smallest addition of the fertilizers, the sodium nitrate and leunasaltpeter were the only materials bringing about increases. The other fertilizers depressed the nitrifying power.

With the second amount of the fertilizers, all the additions depressed the nitrifying power, the leunasaltpeter giving the greatest depressing effect followed by sodium nitrate, nitrophoska and ammonium sulfate, while the urea showed the least depression.

With the largest amounts of the fertilizers, the sodium nitrate was the only material which increased the nitrifying power, the ammonium sulfate and nitrophoska had no effect, and the leunasaltpeter showed some depressive influence.

When the tests were carried out using ammonium sulfate and calcium carbonate, all the fertilizers applied in the smallest amounts, depressed the nitrifying power of the soils. The ammonium sulfate had the least effect and the sodium nitrate came next, the leunasaltpeter and urea showing the greatest depression over the checks.

When the second amount of the fertilizers was used, the nitrifying power was depressed in all cases, the ammonium sulfate showing the least effect. In this case the urea brought about the greatest depression.

With the largest additions of the fertilizers all the treatments depressed the nitrifying power over the first check although the leunasaltpeter showed only a very slight effect. The effects were different, however, if the average of the two checks 7013 and 7019 are taken. Then there appears an increase for the leunasaltpeter and nitrophoska and only slight depressions for the other materials.

The Second Sampling — The results of the nitrification tests at the second sampling on July 6 are given in table II.

The nitrifying power of the soils as measured by the nitrifica-

tion of the soils' own nitrogen varied considerably with the smallest amount of the nitrogen fertilizers, all applications increased in a very pronounced way the nitrifying power, the sodium nitrate showing the greatest effect, with the nitrophoska second.

With the second amount of the fertilizers, all the treatments again showed an increase in nitrification although the ammonium sulfate had practically no effect. Again the sodium nitrate had the most effect, followed closely by the urea and the nitrophoska.

Table II — Nitrification in the Soils on July 6 p. p. m. of Nitrate Nitrogen

Plot No.	Treatment	NO_3N in Soil	Nitrification		
			Soil Alone (A)	Soil + 30 Mgs. $(NH_4)_2SO_4$ (B)	Soil + 30 Mgs. $(NH_4)_2SO_4$ + 210 Mgs. $CaCO_3$ (C)
7001	Check	4.6	16.3	163	290
7002	$NaNO_3$ – 75 lbs.	10.3	28.3	183	296
7003	$(NH_4)_2SO_4$	10.1	24.1	187	272
7004	Urea	7.6	20.8	161	292
7005	Leunasaltpeter	8.9	20.4	215	262
7006	Nitrophoska	15.2	27.1	211	290
7007	Check	11.1	23.4	158	274
7008	$NaNO_3$ – 100 lbs.	21.4	35.3	100	199
7009	$(NH_4)_2SO_4$	11.6	23.9	140	256
7010	Urea	20.7	34.4	171	218
7011	Leunasaltpeter	13.7	31.7	146	251
7012	Nitrophoska	10.1	33.0	236	271
7013	Check	12.1	31.7	163	222
7014	$NaNO_3$ – 200 lbs.	18.3	51.5	178	273
7015	$(NH_4)_2SO_4$	18.7	39.5	171	228
7016	Urea	23.8	50.0	187	216
7017	Leunasaltpeter	22.7	49.3	202	244
7018	Nitrophoska	25.7	49.4	153	223
7019	Check	18.1	44.4	158	232

When the largest applications of the fertilizers were made, the nitrifying power was increased considerably in all cases. The sodium nitrate had the greatest effect but the urea was almost as effective. The ammonium sulfate was the least effective.

When the tests were carried out using ammonium sulfate, again it may be noted that all the nitrogen fertilizers applied in the smallest amounts increased the nitrifying power except the urea, which had no effect. The leunasaltpeter showed the greatest effect and the nitrophoska about the same.

With the second largest addition of the fertilizers, the nitrophoska gave a large increase. The urea showed a small effect, but the other materials all depressed nitrification, the sodium nitrate giving the greatest depression.

With the largest addition of the fertilizers, all but one of the materials increased the nitrifying power of the soil. The nitro-

phoska had no effect. The leunasaltpeter showed the greatest influence.

Testing for the nitrifying power with ammonium sulfate and calcium carbonate gave some interesting results. The sodium nitrate had the greatest effect. The ammonium sulfate and leunasaltpeter decreased the nitrifying power.

When the second largest application of fertilizers was made the sodium nitrate showed a depression in nitrifying power. The urea also showed some depressive effect. The other materials showed some increases but they were not large.

When the largest applications of fertilizers were made, the sodium nitrate increased nitrification the most. The urea and nitrophoska showed a slight depression and the ammonium sulfate had no effect; the leunasaltpeter gave a small increase.

The Third Sampling — The results secured at the third sampling are given in table III.

Table III — Nitrification in the Soils on July 20 p. p. m. of Nitrate Nitrogen

Plot No.	Treatment	NO_3N in Soil	Nitrification		
			Soil Alone (A)	Soil + 30 Mgs. $(NH_4)_2SO_4$ (B)	Soil + 30 Mgs. $(NH_4)_2SO_4$ + 210 Mgs. $CaCO_3$ (C)
7001	Check	30.6	51.6	127	335
7002	$NaNO_3$ – 75 lbs.	19.5	36.0	104	276
7003	$(NH_4)_2SO_4$	14.7	30.8	117	271
7004	Urea	18.9	37.2	180	299
7005	Leunasaltpeter	26.7	40.0	139	302
7006	Nitrophoska	34.9	40.3	115	287
7007	Check	23.3	39.9	127	276
7008	$NaNO_3$ – 100 lbs.	34.9	50.2	125	302
7009	$(NH_4)_2SO_4$	31.2	50.0	116	297
7010	Urea	30.2	47.8	122	286
7011	Leunasaltpeter	41.2	58.6	134	349
7012	Nitrophoska	30.0	53.4	141	320
7013	Check	21.5	53.4	145	348
7014	$NaNO_3$ – 200 lbs.	44.4	56.2	146	341
7015	$(NH_4)_2SO_4$	16.3	46.5	134	287
7016	Urea	29.1	40.6	123	281
7017	Leunasaltpeter	33.6	54.2	108	286
7018	Nitrophoska	37.3	51.6	127	288
7019	Check	16.0	37.6	170	297

When the soil alone was tested, the smallest additions of the nitrogen fertilizers seemed to depress the nitrifying power of the soils in all cases, showing the greatest effect in the case of the ammonium sulfate.

With the second amount of fertilizers all the materials increased nitrification, the leunasaltpeter having the greatest effect.

With the largest application of fertilizers, all but one of the treat-

ments increased the nitrifying power over that shown by the average of the two adjacent checks. The urea depressed nitrification. The sodium nitrate gave the greatest increase.

Considering the results of the tests using ammonium sulfate, all the smallest additions of the various nitrogen fertilizers depressed nitrification except in the case of the urea, which gave a large increase and the leunasaltpeter, which had a small effect. The sodium nitrate gave the greatest depression.

With the second amount of the fertilizers the nitrophoska was the only material showing a beneficial effect. The other fertilizers showed depressions, the ammonium sulfate giving the greatest depression.

When the largest additions of fertilizers were used, all the treatments depressed the nitrifying power, the leunasaltpeter showing the greatest depression.

When the tests were carried out with ammonium sulfate and calcium carbonate, again the smallest additions of the nitrogen fertilizers reduced the nitrifying power in all but one case where there was no effect.

With the second largest addition of the fertilizers the leunasaltpeter and nitrophoska increased the nitrifying power of the soils, the former material showing the greatest effect. This comparison is made against the average of the two adjacent checks. The urea showed the greatest depression.

With the largest amount of the fertilizers, all the materials depressed nitrification except the sodium nitrate.

The Fourth Sampling — The results secured at the fourth sampling are given in table IV.

At this sampling when the soil alone was used in the tests, the smallest additions of the nitrogen fertilizers increased in nitrifying power over that in the check (average of the adjacent checks) only in the case of the urea. The sodium nitrate showed a depression and the other materials little effect.

With the second largest amounts of the fertilizers the nitrophoska gave a very large gain, so large that it is probably an abnormal result. All the other materials depressed the nitrifying power comparing with the average of the adjacent checks.

With the largest additions of the fertilizers, the sodium nitrate gave a large increase in nitrifying power. The ammonium sulfate also showed an increase but the leunasaltpeter and nitrophoska depressed the process.

When the ammonium sulfate test for nitrification was employed

the urea in the smallest amount gave the greatest increase, followed by the sodium nitrate and leunasaltpeter. The ammonium sulfate showed a decrease.

When the second amount of the fertilizers was employed there was a depression in all cases, the urea giving the greatest depression and the nitrophoska the least.

When the largest additions of the nitrogen fertilizers were made the sodium nitrate increased the nitrifying power. All the other materials gave a depression.

Table IV — Nitrification in the Soils on August 24 p. p. m. of Nitrate Nitrogen

Plot No.	Treatment	NO_3N in Soil	Nitrification		
			Soil Alone (A)	Soil + 30 Mgs. $(NH_4)_2SO_4$ (B)	Soil + 30 Mgs. $(NH_4)_2SO_4$ + 210 Mgs. $CaCO_3$ (C)
7001	Check	2.0	22.1	154	321
7002	$NaNO_3$ – 75 lbs.	2.8	23.9	216	333
7003	$(NH_4)_2SO_4$	6.9	30.8	160	348
7004	Urea	11.3	38.2	250	302
7005	Leunasaltpeter	4.6	30.2	216	297
7006	Nitrophoska	6.9	29.2	154	297
7007	Check	13.2	37.4	187	348
7008	$NaNO_3$ – 100 lbs.	17.1	39.1	186	382
7009	$(NH_4)_2SO_4$	17.9	42.2	155	302
7010	Urea	2.8	29.7	125	286
7011	Leunasaltpeter	7.8	43.3	152	287
7012	Nitrophoska	12.8	100.0	191	315
7013	Check	23.3	66.6	216	308
7014	$NaNO_3$ – 200 lbs.	32.8	80.0	236	333
7015	$(NH_4)_2SO_4$	24.8	61.0	191	341
7016	Urea	15.9	41.8	167	264
7017	Leunasaltpeter	6.4	25.0	164	272
7018	Nitrophoska	3.6	25.8	160	258
7019	Check	5.6	34.8	200	364

When the test was carried out with ammonium sulfate and calcium carbonate, the ammonium sulfate fertilizer in the smallest amount gave an increase in nitrifying power and the other materials no effect or a slight depression.

When the larger additions of the fertilizers were made the sodium nitrate increased the nitrifying power considerably. The other materials had no effect or a depression was noted.

With the greatest amounts of the fertilizers, no increases were secured. The sodium nitrate and ammonium sulfate had no effect and the other materials gave pronounced depressions.

THE AVERAGE RESULTS

The average results for the nitrification tests at the four samplings by the three methods are given in table V.

With the smallest application of the fertilizers, the urea was the only material which increased definitely the nitrifying power as measured in the soil alone, the other fertilizers showing little or no effect. With the ammonium sulfate method all the treatments increased the nitrifying power, the leunasaltpeter having the greatest effect and the ammonium sulfate the least influence. When the method using ammonium sulfate and calcium carbonate was employed none of the treatments increased the nitrifying power and all depressed the process, the leunasaltpeter showing the least depression.

Table V — Average Nitrification Data for the Four Samplings p. p. m. Nitrogen

Plot No.	Treatment	Soil Alone	Soil + 30 Mgs. $(NH_4)_2SO_4$	Soil + 30 Mgs. $(NH_4)_2SO_4$ + 210 Mgs. $CaCO_3$
7001	Check	28.6	156.7	319.5
7002	$NaNO_3$ – 75 lbs.	27.5	182.7	297.0
7003	$(NH_4)_2SO_4$	28.0	158.0	302.5
7004	Urea	40.1	188.5	291.0
7005	Leunasaltpeter	28.7	208.7	278.7
7006	Nitrophoska	31.3	163.6	286.5
7007	Check	31.8	155.5	312.7
7008	$NaNO_3$ – 100 lbs.	39.7	136.2	267.2
7009	$(NH_4)_2SO_4$	37.9	137.5	286.5
7010	Urea	35.7	140.2	261.2
7011	Leunasaltpeter	42.6	136.5	292.0
7012	Nitrophoska	37.7	176.0	300.7
7013	Check	47.2	167.5	295.5
7014	$NaNO_3$ – 200 lbs.	54.8	179.0	302.0
7015	$(NH_4)_2SO_4$	43.2	160.0	281.0
7016	Urea	40.8	154.0	283.0
7017	Leunasaltpeter	40.7	149.2	276.2
7018	Nitrophoska	40.5	146.0	263.7
7019	Check	36.7	156.0	284.5

With the second largest amounts of the fertilizers, using the soil alone, the leunasaltpeter was the only material increasing the process and the urea gave a distinct depression. With the ammonium sulfate method, the nitrophoska was the only material which increased the process, while all the other material brought about distinct depressions, the sodium nitrate and leunasaltpeter having the greatest depressive effect. When the ammonium sulfate plus calcium carbonate method was employed none of the materials stimulated nitrification but on the contrary all showed a depression, the urea and sodium nitrate having the greatest effect.

When the largest applications of the fertilizers were made the test in the soil alone showed sodium nitrate to be the only material increasing the nitrifying power. The other materials showed slight

depressions. By the ammonium sulfate method the results were the same, the sodium nitrate being the only material to stimulate nitrification, the other materials again depressing the process. And finally by the ammonium sulfate plus calcium carbonate method the results were the same, the sodium nitrate increasing nitrification while all the other fertilizers depressed the process, the leunasaltpeter having the greatest depressive effect.

The results as a whole show quite clearly that the results of nitrification studies may be somewhat dependent upon the method used.

The smallest amounts of the fertilizers added showed no effect on the process except when the ammonium sulfate test was used, in which case a stimulation was evidenced for all the materials. With the second largest amounts of the fertilizers none of the materials stimulated the process by any of the methods employed except in two cases where the effects were not great.

With the largest additions of the fertilizers the results show a stimulation of nitrification with the sodium nitrate and not with any of the other materials, no matter which method is employed. So it may be considered that the sodium nitrate applied at the rate of 200 pounds per acre stimulated nitrification in this soil. The other nitrogen fertilizers did not do so. With the smaller amounts, no increases were secured in general from any of the fertilizers.

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