

POT EXPERIMENTS TO DETERMINE THE LIMITS OF ENDURANCE OF DIFFERENT FARM-CROPS FOR CERTAIN INJURIOUS SUBSTANCES.

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Part III.—BARLEY AND RYE.

THE experiments which form the subject of the present communication were carried out last year and are in continuation of those already communicated to you with regard to wheat and maize.¹ They were conducted in precisely the same manner, and it will be unnecessary to go into the detail of the methods adopted which will be found in full in this Journal, xxxvi., p. 191.

The soil with which the pots were filled was a rich garden loam mixed with a nearly equal quantity of light sand. Each pot received a manuring of 10 grms superphosphate, and all were exposed to precisely the same conditions as to light, warmth, water, etc., throughout the course of the experiment. Check pots were filled and sown in exactly the same way, except that the deleterious substances were omitted.

III. BARLEY—*Experiments with Common Salt.*

Eight pots were filled with the soil together with a light manuring with superphosphate and the following quantities of common salt per 100 lbs. of soil:—

No. 84,	·10	per cent. NaCl.
„ 85,	·15	„ „
„ 86,	·20	„ „
„ 87,	·25	„ „
„ 88,	·30	„ „
„ 89,	·35	„ „
„ 90,	·40	„ „
„ 91,	·50	„ „

¹ This Journal, xxxvi., p. 191, and xxxvii., p. 165.

The pots were sown on December 3rd, 1902, with 13 grains of barley in each pot, the surface being covered as in the other experiments with a mulch of shredded coconut fibre and the soil kept moist during the experiment.

The following notes were made on December 13th with regard to the growth of the plants :—

In No. 84 the seeds had germinated well, but the growth had already been affected.

In Nos. 85 and 86, the plants had germinated weakly and the growth was very poor. In the remaining pots the seed had not germinated at all.

From these experiments it would appear that the limits both to growth and germination had been struck, the growth being affected by $\cdot 10$ per cent. NaCl and the germination at about $\cdot 25$ per cent.

Further pots were sown on July 30th, 1903, with the following quantities of salt :—

No. 92, $\cdot 05$ per cent.

„ 93, $\cdot 07$ „

„ 94, $\cdot 10$ „

„ 95, $\cdot 15$ „

These were examined August 21st, 1903, when the following notes were made :—

No. 92, germination unaffected and growth unaffected.

No. 93, germination unaffected, growth very slightly affected.

No. 94, the germination had been slightly affected and the growth retarded.

No. 95, germination was weak and the growth was poor.

Examination of the pots a month later, September 29th, 1903, showed that in Pot No. 92, the growth was quite unaffected and the plants were growing vigorously.

In Nos. 93 and 94, the plants had recovered and were apparently as healthy as the control pots, whereas in Pot No. 95 the growth was affected.

From the above it is concluded that the germination of barley is affected by about $\cdot 1$ per cent. NaCl, and entirely prevented by the presence of $\cdot 25$ per cent. The growth is affected by as little as $\cdot 07$ per cent. NaCl, but with this quantity and up to $\cdot 15$ or $\cdot 20$ per cent. the plants may recover under favourable conditions. With $\cdot 20$ per cent. the growth is prevented.

Experiments with sodium carbonate.

Eight pots were filled with soil, manured with superphosphate and sown on December 3rd, 1902, with 13 grains of barley. Sodium carbonate had previously been added in the following proportions:—

No. 96,	$\cdot 1$	per cent.	Na_2CO_3
„ 97,	$\cdot 2$	„	„
„ 98,	$\cdot 25$	„	„
„ 99,	$\cdot 30$	„	„
„ 100,	$\cdot 35$	„	„
„ 101,	$\cdot 40$	„	„
„ 102,	$\cdot 50$	„	„
„ 103,	$\cdot 60$	„	„

The appearance of these pots on December 13th, when they were examined was as follows:—

Germination had not been affected in pots 96 and 97.

In pot 98 the germination had been slightly retarded, though all the seeds had germinated.

In the remaining pots the germination was less vigorous and in pot 103 the seeds did not germinate at all.

In pot 96, the plants were growing well. In 97 the growth was slightly affected, the effect increasing with increase of sodium carbonate up to pot 101. In this and the succeeding pots the plants had died.

In order to determine within narrower limits the point at which the growth commenced to show signs of being influenced by the presence of carbonate of soda, 3 additional pots were sown on July 30th, 1903, containing respectively:

No. 104 ·1 per cent. sodium carbonate.

„ 105 ·15 „ „

„ 106 ·2 „ „

On August 21st, 1903, when these pots were examined, the germination was unaffected in all three. In pot 104 the growth was quite vigorous and unaffected; in No. 105 the growth was slightly affected, and in No. 106 somewhat more so.

From the above it is concluded that germination of barley is not affected by quantities of carbonate of soda up to ·25 or ·30, and is absolutely prevented by ·60 per cent. carbonate of soda in the soil. The subsequent growth of the plant is not affected by quantities below ·15 per cent., at which point the effects of carbonate of soda are distinctly noticeable. ·4 per cent. and over prevent the growth of barley.

Experiments with ammonium sulphocyanide.

Six pots were filled and sown on December 3rd, 1902, as in the preceding experiments, the following quantities of ammonium sulphocyanide having been added previous to sowing :—

No. 107, ·001 per cent. NH_4CNS .

„ 108, ·002 „ „

„ 109, ·003 „ „

„ 110, ·004 „ „

„ 111, ·005 „ „

„ 112, ·006 „ „

In all these cases the germination was unaffected and the plants were growing vigorously on December 13th in all pots except Nos. 111 and 112, in which the growth was affected.

Another series of 5 pots was sown on July 30th with freshly prepared ammonium sulphocyanide, as the solution of cyanide used in the above series had been in stock for some time, and it was thought probable that it had undergone decomposition:—

No. 113, '007 per cent, ammonium sulphocyanide.

„ 114, '008	„	„	„
„ 115, '009	„	„	„
„ 116, '010	„	„	„
„ 117, '012	„	„	„

In none of these cases did the plants germinate, the results are consequently inconclusive and the experiments will have to be repeated.

Experiments with sodium chlorate.

Pots were filled as follows:—

No. 118, '001 per cent. sodium chlorate.

„ 119, '002	„	„
„ 120, '003	„	„
„ 121, '004	„	„
„ 122, '005	„	„
„ 123, '006	„	„

All pots germinated well, except Nos. 122 and 123 in which the germination was much retarded and the plants very weak. On December 13th, the plants in Nos. 118 and 119 were growing well when examined. In No. 120 the growth was good, but the leaves had a tinge of yellow at the tips.

In 121 and 122 the growth was markedly affected, and in 123 the plants were dying. In these three last pots the leaves were distinctly yellow.

Three additional pots were sown on July 30th, 1903, with larger preparations of chlorate:—

No. 124, '006 per cent. sodium chlorate

„ 125, '007	„	„
„ 126, '008	„	„

In none of these cases did the plants germinate.

It appears from the above that in the case of barley, germination is affected by the presence of '005 per cent. sodium chlorate in the soil, and entirely prevented when '006 or '007 is present. The effect of this substance is apparent when '003 per cent. is present, and when it reaches '006 the growth of barley is prevented.

Experiments with arsenious acid.

Six pots received varying proportions of arsenious acid on December 3rd, 1902, as follows:—

No. 127, '10 per cent. As_2O_3

„ 128, '20 „ „

„ 129, '30 „ „

„ 130, '40 „ „

„ 131, '50 „ „

„ 132, '60 „ „

All plants germinated fairly well, but the growth was found (December 13th, 1902) to have been affected by the smaller quantity of arsenic taken, No. 127 being very slightly affected. No. 128 slightly affected, and in No. 129 the growth of the plants was much affected, the effect being more marked with the increase of arsenic in the remaining pots.

Additional pots were resown on July 30th, as follows:—

No. 133, '05 per cent. As_2O_3

„ 134, '06 „ „

„ 135, '10 „ „

When examined on August 21st, 1903, the germination was practically unaffected in all cases, but the effect on the growth was already strongly marked in the case of No. 133. In No. 135 the growth was very strongly affected. By September 29th, 1903, when the pots were again examined, pots 133 and 134 had recovered and were growing vigorously though not quite as strongly as the control pot. In No. 135 however, the plants were almost dead.

The results with barley are tabulated below :—

Effect upon germination and subsequent growth of Barley of different percentages of injurious substances in the soil.

	Germination affected	Germination prevented	Growth affected	Growth prevented
NaCl	·1	·25	·10	·20
Na ₂ CO ₃	·25	·60	·15	·40
NH ₄ CNS	inconclusive			
NaClO ₃	·005	·007	·003	·006
As ₂ O ₃	germination unaffected by ·6		·05	·10

IV. RYE—*Experiments with NaCl.*

Five pots were filled with soil, to which was added 10 grms superphosphate per pot, and the following quantities of sodium chloride :—

No. 136, ·05 per cent.

„ 137, ·10 „

„ 138, ·15 „

„ 139, ·20 „

„ 140, ·25 „

These pots were sown on August 6th, 1903, in the usual manner, the surface being covered with a mulch of shredded coco-nut fibre and the soil kept moist throughout the experiment. A check pot was sown at the same time.

The pots were examined in August 21st, when the following observations were made :—

In No. 136 the plants had germinated well but the growth was rather backward compared with that in the check-pot.

In No. 137, the germination was already affected and the growth considerably retarded.

In the remaining three pots both germination and subsequent growth were very markedly affected.

The pots were again examined on September 29th, 1903, when it was found that the plant in pots 136 and 137 had recovered and were apparently making as vigorous growth

as the check-pot. In pot 138, however, the growth was strongly affected. In pot 139 the plants were nearly dead, and in No. 140 they were quite dead.

These experiments showed that germination of rye is already affected by the presence in the soil of $\cdot 1$ per cent. NaCl, it was not however, prevented by amounts up to $\cdot 25$ per cent. The subsequent growth of rye is affected by $\cdot 05$ per cent., but under favourable conditions the plants may recover in the presence of sodium chloride up to $\cdot 1$ per cent. With $\cdot 15$ per cent. the subsequent growth is strongly affected and with $\cdot 20$ per cent. the plants die.

In order to ascertain the amount necessary to prevent germination, a further series of four pots were sown on October 10th, 1903, with the following proportions of common salt:—

No. 141,	$\cdot 30$	per cent. NaCl
„ 142,	$\cdot 35$	„ „
„ 143,	$\cdot 40$	„ „
„ 144,	$\cdot 50$	„ „

It was found on examining these pots on October 21st, that the germination in Nos. 141 and 142 had been strongly affected, and that in No. 143 the plants had hardly germinated at all, the germination being still more feeble in No. 144.

By December 4th, the plants in all pots were dead. Germination of rye is therefore prevented by $\cdot 4$ per cent. NaCl and over.

Experiments with Na_2CO_3 .

On 6th August, 1903, six pots were filled with the soil, 10 grms superphosphate to each pot, and the following quantities of sodium carbonate, and 13 grains of rye:—

No. 145,	$\cdot 1$	per cent.
„ 146,	$\cdot 2$	„
„ 147,	$\cdot 25$	„
„ 148,	$\cdot 30$	„
„ 149,	$\cdot 85$	„
„ 150,	$\cdot 40$	„

The following notes were made on August 21st:—The germination was unaffected in pots 145 and 146; slightly affected in 147 and more strongly in the remainder. The early growth was slightly affected in pots 145, 146, 147, and more strongly affected in the remaining three.

On September 29th, the plants in 145, 146, and 147 had recovered and were growing as vigorously as the check-pots; in No. 148 the growth was strongly affected, in 149 the plants were very feeble, and in 150, very nearly dead.

In order to arrive at the point at which germination was prevented, three more pots were sown on October 10th as follows:—

No. 151,	·4	per cent	Na_2CO_3
„ 152,	·45	„	„
„ 153,	·50	„	„

On October 21st the germination in pot No. 151 was strongly affected; in pot 152 the germination was still more strongly affected, and in pot 153 the plants had hardly germinated at all. By December 4th, 1903, when the pots were again examined, the plants were all dead.

It is therefore, concluded that in the case of rye, germination is affected by the presence of ·25 per cent. Na_2CO_3 , and prevented when ·5 per cent. is present. ·1 per cent. is sufficient to check the early growth of the plant, but under favourable conditions the plants will recover with quantities up to ·25 per cent., above this point, however, the subsequent growth of rye is affected, and in the presence ·4 per cent. the plants die.

Experiments with ammonium sulphocyanide.

The following pots were prepared and filled with soil as usual, manured and sown on August 6th, 1903:—

No. 154,	·004	per cent.	NH_4CNS .
„ 155,	·005	„	„
„ 156,	·006	„	„
„ 157,	·007	„	„
„ 158,	·008	„	„

The pots were examined on August 21st, when it was found that in all cases the germination was very weak and the young shoots had withered almost as soon as they appeared above ground.

The pots were consequently resown on October 10th with the following quantities:—

No. 159,	·001	per cent.	NH ₄ CNS.
„ 160,	·002	„	„
„ 161,	·003	„	„
„ 162,	·004	„	„

On examining these pots on October 21st, it was found that the germination was unaffected in all cases. Pots 159 and 160 were growing well, but the growth was affected in No. 161, and more strongly in 162, the leaves beginning to curl and the tips to wither.

On December 4th, when re-examined, all plants had apparently recovered and were doing well. The results therefore, with ammonium sulphocyanide are not conclusive and will require to be repeated. Germination appears to be affected by quantities above ·004 per cent. and the growth of the plants affected by ·003 per cent., with this quantity and up to ·004 the plants may recover under favourable conditions. Above ·004 the plants do not recover.

Experiments with sodium chlorate.

The following pots were prepared and sown on August 6th, 1903, sodium chlorate being applied in the under-mentioned quantities:

No. 163,	·002	per cent.	NaClO ₃
„ 164,	·003	„	„
„ 165,	·004	„	„
„ 166,	·005	„	;
„ 167,	·006	„	„

The pots were examined on August 21st, when it was found that pots 163 and 164 had germinated well. In 165

the germination was slightly affected, and in 166 and 167 the germination was very weak—in pot 167 the plants hardly germinated. In all cases, even in pots 163 and 164, the subsequent growth was very feeble and the plants were nearly dead. In pots 166 and 167 the plants were quite dead.

Two more pots were therefore sown on October 10th with smaller quantities of NaClO_3 in order to determine the point at which the growth commenced to be affected.

No. 168, .001 per cent. NaClO_3

„ 169, .002 „ „

These pots were examined in October 21st, when both had germinated well. In pot 168 the growth was unaffected and in No. 169 the growth was slightly affected. By December 4th, when the pots were again examined, the plants in both cases had recovered and were growing well.

From these it is concluded that germination is unaffected by NaClO_3 in the case of rye by quantities below .004 per cent., the presence of .006 per cent. preventing germination. The subsequent growth of the plants is affected by .002 per cent., but under favourable conditions the plants can recover. Growth is prevented by .004 per cent.

Experiments with arsenious acid.

The following 5 pots were filled with soil, manured and sown on August 6th with varying quantities of arsenious acid :—

No. 170, .05 per cent. As_2O_3

„ 171, .10 „ „

„ 172, .20 „ „

„ 173, .30 „ „

„ 174, .40 „ „

When examined on August 21st, the following appearances were noted:—In pots Nos. 170 and 171 the plants germinated freely. In 172 the germination was retarded. In 173 and 174 the germination was very feeble, and in No. 174 the

plants had hardly germinated at all. The plants were growing well in No. 170, but the growth was already affected in No. 171, and in the remaining pots the plants were very feeble and in 173 and 174 nearly dead.

Subsequent examination of the pots on October 10th showed the plants in No. 170 to be growing normally and equal to the check-pots. The plants in No. 171 had recovered and were apparently quite as healthy as those in the check-pots. In No. 172 the growth was affected (stunted) and in 173 and 174 the plants were dead.

The conclusions drawn are that germination in the case of rye is unaffected by quantities of arsenic below .2 per cent. With .2 per cent germination is affected, and about .4 or a little over prevents germination. The subsequent growth of rye is not affected until the amount of arsenic in the soil reaches .15 per cent. at which point the effects of its presence are marked, and with .30 per cent. the growth of rye is prevented.

The results of the experiments with rye are presented in the following table:—

Effect upon germination and subsequent growth of Rye of different percentages of injurious substances in the soil.

	Germination affected	Germination prevented	Growth affected	Growth prevented
NaCl	.10	.40	.15	.20
Na ₂ CO ₃	.25	.50	.25	.40
NH ₄ CNS	inconclusive			
NaClO ₃	.004	.006	.002	.004
As ₂ O ₃	.2	above .4	.15	.30



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