7. Thus far this investigation has thrown some new light upon the chemistry of fatigue, but much additional work is yet to be done before the theoretical discussion of the results may be profitably entered upon. The inquiry will be further pursued in this laboratory.

In conclusion the authors acknowledge their sincere thanks for assistance rendered by Messrs. F. C. Beall, O. D. Hargis, H. Kuehne, and M. B. Wesson.

NOTE.—This communication is dated June, 1902, because the experimental part was complete by that time. However, the results were not put in their present shape for publication until September, 1902, the duties incident to the close of the session making it impossible to shape the results at an earlier date.

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ON THE FIXATION OF AMMONIA AND POTASH BY HAWAIIAN SOILS.

BY J. T. CRAWLEY AND R. A. DUNCAN.

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IN this Journal, **24**, 1114, will be found a paper by the writer on the "Fixation of Phosphoric Acid in the Soil." This paper will record results on the fixation of the other chief fertilizer constituents, ammonia and potash. The same methods described in that work were followed in these experiments, and the results, therefore, can be compared with each other. The main object is to find the depth in the soil at which the chief fertilizing materials are fixed and to determine the loss by drainage when the application is followed by a heavy irrigation. A given weight of the commercial article containing ammonia and potash, namely, sulphate of ammonia and sulphate of potash, is applied to the soil, and this is irrigated with 3 or 4 inches of water (the usual irrigation as practiced on the plantations), the drainage collected and analyzed. The difference between the amount applied and that found in the drainage is the amount abstracted or held by the soil. By varying the depth of soil we find the depth at which the ingredients are fixed. Boxes (9 inch cube) with holes in the bottom for the escape of water were used in the experiment. In all cases

4800 cc. of water were poured upon the soil, and the time necessary for the excess to drain off is given.

I. FIXATION OF AMMONIA.

Ten grams of commercial sulphate of ammonia, containing 2.478 grams ammonia were used in each case.

(1) Six inches of soil; the sulphate was scattered over the soil and 4800 cc. water were added; 1130 cc. drained through within seventeen minutes, containing 0.0038 gram ammonia or 0.155 per cent. of total applied.

(2) Four inches of soil; drainage was completed in twelve minutes; 2180 cc. water passed through, containing 0.0464 gram ammonia or 1.387 per cent. of total.

(3) Two inches of soil; drainage was completed in thirteen minutes; 3280 cc. water were recovered, containing 0.3400 gram ammonia, or 13.88 per cent of total.

(4) One inch of soil; drainage was completed in seventeen minutes; 4000 cc. water were recovered, containing 1.2328 grams ammonia, or 49.79 per cent. of total.

Putting these results together, we have:

TABLE I.—FIXATION OF AMMONIA.

Depth of soil. Inches.	Ammonia retained. Per cent.
6	99.85
4	98.13
2	86.12
1	50.21

In these experiments we see that with irrigation following the application of sulphate of ammonia, one-half is retained in the first inch, more than four-fifths within the first 2 inches and almost all within 4 inches of soil.

In order to determine if the ammonia retained has been firmly fixed and is insoluble in water, the 1 inch of soil which had already been irrigated once was subjected to further irrigations, with the following results:

TABLE II.—AMOUNT OF AMMONIA WASHED FROM THE FIRST INCH OF SOIL BY SUCCESSIVE IRRIGATIONS.

Number of irrigations.	Ammonia washed out. Grams.	Per cent.
First	1.2328	49.79
Second, three days after first	0.1937	7.8
Third, one hour after second	0.1249	5.0
Fourth, nineteen hours after third	0.0904	3.6
Fifth, one hour after fourth	0.0581	2.3
Total, five irrigations	1.6999	68.49

The ammonia is held rather firmly, but subsequent irrigations wash it out in decreasing quantities.

II. FIXATION OF POTASH.

Ten grams sulphate of potash containing 4.8 grams actual potash were scattered over the soil, and water was poured over, as in preceding tests.

TABLE III.—FIXATION OF POTASH.

Depth of soil. Inches.	Potash retained. Per cent.
6	98.55
4	94.18
2	82.03
1	69.19

Seven-tenths of the potash applied is retained in the first inch, more than four-fifths in 2 inches and almost all within 6 inches of the soil. The box containing 6 inches of soil which had been irrigated once, was subjected to further irrigations to see if the potash is held firmly.

TABLE IV.—AMOUNT OF POTASH WASHED FROM SIX INCHES OF SOIL BY SUCCESSIVE IRRIGATIONS.

Number of irrigation.	Potash washed out. Grams.	Per cent.	Potash in 1000 cc. drainage. Grams.
First	0.0697	1.45	0.0680
Second, 4 days after first	0.1631	3.4	0.2044
Third, 1 hour after second	0.1659	3.5	0.0361
Fourth, 16 hours after third	0.1302	2.7	0.0296
Fifth, 1 hour after fourth	0.1139	2.4	0.0243
Sixth, 7 days after fifth	0.0929	1.9	0.0251
Seventh, 2 days after sixth	0.0948	2.0	0.0228
Eighth, 7 days after seventh	0.0967	2.0	0.0215
Total, 8 irrigations	0.9272	19.35	

As the moisture content of the soil varies, the amount of drainage will vary. Therefore I have included in the table the amount of potash in each 1000 cc. of drainage. As in the case of ammonia, the potash is held rather firmly but irrigations gradually wash it away, light irrigations having washed 19 per cent. out of 6 inches of soil.

Below will be found the results on phosphoric acid, ammonia, and potash.

TABLE V.—FIXATION OF PHOSPHORIC ACID, AMMONIA AND POTASH.

Depth of soils.	Phosphoric acid retained. Per cent.	Ammonia retained. Per cent.	Potash retained. Per cent.
6	99.43	99.84	98.55
4	....	98.13	94.18
3	91.25	....	....
2	....	86.12	82.03
1	53.35	50.21	69.19

These results have a great practical bearing on plantation work in these islands. Many of the plantations depend upon irrigation entirely, and a great deal of the water, as I have shown in an article in the August number of the *Hawaiian Planter's Monthly* on "The Water-Holding Power, and the Irrigation of Hawaiian Soils," passes directly and immediately through the soils. In other cases, as in the Hilo district, the soils are subjected to very heavy rains. Were the soluble fertilizer ingredients not fixed at once the loss would be very great; but the experiments show that even under heavy washings they are fixed very rapidly. But the solubility of these substances in water after the first irrigation, though slight, emphasizes the importance of keeping the irrigation well under control. The nitrogen of sulphate of ammonia is gradually changed to nitrate, and most of that which the plant has not assimilated is washed away by the first irrigation or heavy rainfall. The phosphoric acid is more firmly bound, and the loss of this substance is very slight. Under the conditions of the tests, 19 per cent. of the potash applied as sulphate was washed below 6 inches by eight irrigations.

We thus see that heavy and repeated irrigations wash out the available ammonia and potash; and this will partially account for the fact that very often the effects of a fertilizer, especially of a nitrogenous fertilizer, are not lasting.

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A PROBABLE CAUSE OF THE DIFFERENT COLORS OF IODINE SOLUTIONS.

BY ARTHUR LACHMAN.

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IT is a well-known fact that solutions of free iodine have different colors, depending in some way upon the nature of the solvent.