

Studies on Soil Reaction and the Growth of *Astragalus sinicus* (Genge).

By

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This paper deals with the relation of soil reaction on the growth of *Astragalus sinicus* (Genge)† which is the most important green manure for the paddy-field on account of its adaptability for such field conditions as peculiar to the paddy-field. As it is well known, the soil in the paddy-field contains a large amount of water throughout a year and is acid in reaction in most cases as shown previously¹⁾. It was investigated here to ascertain to what extent the growth of *Astragalus sinicus* is influenced by the concentration of hydrogen ions in soils.

Experimental :

The soils from the experimental plots at this institute were taken and the reaction was adjusted for certain P_H by adding acid or alkali, and the buffer capacity of the soils was determined at the sametime.

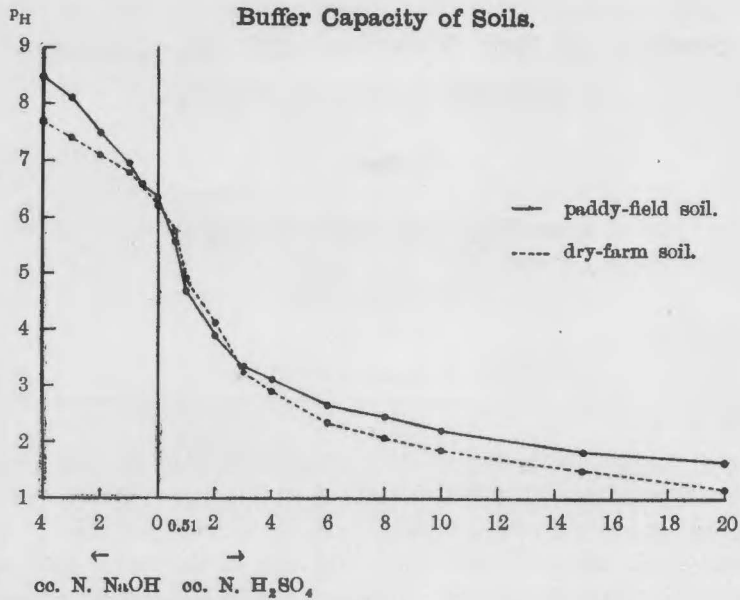
Determination of Buffer Capacity of Soils.

As a preliminary test for adjusting the soil reaction, the buffer capacity of soils from the paddy-field and dry-farm at this institute was determined as follows :

100 g. soil was placed in a 300 cc. Erlenmeyer flask and various amount of N/1 H_2SO_4 and N/1 NaOH respectively and a certain amount of water was added in each to make 1 : 2 (soil : water) soil extract, and P_H was determined in the soil extract by the quinhydrone method. In case of sulfuric acid, it was added in ten different portions while sodium hydroxide, in five as indicated in Fig. 1.

† Japanese name.

Fig. 1.



As Fig. 1 shows, no appreciable difference is noted between the paddy-field and dry-farm soil as to their buffer capacity which is rather strong in both cases. The dry-farm soil has somewhat stronger buffer capacity against the alkali and weaker toward the acid than the paddy-field soil.

Growth of Astragalus sinicus and Hydrogen Ion Concentration.

The soil from the paddy-field which was air dried having the following properties, was used for the experiment :

Moisture content	5.087%
Water holding capacity	66.0%
Total nitrogen	0.148%
P _H	6.15

In a small pot, 2,250 g. soil was placed and the hydrogen ion concentration of the soil was adjusted by adding either sulfuric acid or sodium hydroxide, and the moisture content was adjusted to 30% which was found to be the optimum²⁾ for the growth of *Astragalus sinicus*. The 30% moisture corresponds, more or less to 50% the water holding capacity of the soil in this case. The pot thus prepared was left for a week so that the reaction is stabilized. After the initial reaction was determined by the quinhydrone method, one hundred seeds were planted in each of 18 pots of which P_H values ranged from 3.0 to 9.0 as indicated in Table I, and the pots were prepared in duplicates A & B as close as possible. The pots were

kept in the greenhouse and the water was supplied every other day so that the constant weight was maintained. The germination and growth condition were observed constantly.

Results.

Eighteen days after planting, the germination of seeds were examined and found to be as indicated in Table I :

Table I.
Number of Seeds Germinated.

Series.	No. of Pots.	1	2	3	4	5	6	7	8	9
A		—	—	8	27	31	30	19	7	—
B		—	—	4	30	34	24	23	5	—

Table I indicates that no germination took place in Pots 1, 2 and 9.

After a month, the growth was examined and the results are noted in Table II :

Table II.
Number of Plants Grew.

Series.	No. of Pots.	1	2	3	4	5	6	7	8	9
A		—	—	—	17	25	24	14	2	—
B		—	—	—	15	23	18	17	3	—

As Table II indicates, in Pot 3 both A & B, the germinated seeds failed to grow, and also in the others, some failed to grow. For example, in Pots 5, 6 and 7 the number of plants decreased, but whatever grew made fine growth.

The growth was examined after 48 days and found that Pot 7 was the best and in Pot 8, the number of plants was small but the growth was very good next to that in Pot 7. This may be the result of survival of fittest. The growth condition is shown in the photograph. (Plate XXXXII.)

The results of germination and growth may be summarized as follows :

The seeds of *Astragalus sinicus* germinate in p_H 4.2—7.9 and the optimum being p_H 5.6 which was the case in Pot 5. However the growth itself was better in Pot 6 and 7 which indicates that p_H 6.15 was better suited for the growth.

Inspection of Crop.

Fifty seven days after planting, the plants were pulled out and separated from the soil and the following examinations were made :

- 1) Change in the hydrogen ion concentration from the time of planting.
- 2) Relation between the hydrogen ion concentration of soil and that of the plant juice.
- 3) Influence on the nitrogen content of the soil by the crop of *Astragalus sinicus*.

The hydrogen ion concentration was determined by the quinhydrone method ; the plant juice was prepared by the use of press ; and the nitrogen, by Kjeldahl method. The results are noted as follows :

Table III.
pH of Soils and Plant Juice, and Nitrogen
Contents of Soils.

No. of Pots.		1		2		3		4		5		6		7		8		9	
Series.		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
pH of Soils.	Initial.	2.84	2.92	3.67	3.70	4.21	4.23	5.26	5.28	5.65	5.67	6.15	6.15	6.86	6.82	7.86	7.90	8.63	9.55
	Final.	3.72	3.74	3.94	4.01	4.48	4.48	4.86	4.96	5.37	5.42	5.99	6.01	6.29	6.27	7.20	7.36	7.74	9.34
pH of Plant juice		—	—	—	—	—	—	6.17	6.17	6.07	6.13	6.12	6.15	6.10	6.29	6.24	6.20	—	—
T. N. of Soils.	% Air dried.	0.144	0.147	0.146	0.146	0.145	0.149	0.146	0.149	0.149	0.150	0.169	0.159	0.166	0.155	0.149	0.148	0.146	0.147
	% N ±	—	—	—	—	—	+	—	+	+	+	+	+	+	+	+	—	—	—
	N ± per Pot.	90.0	22.5	45.0	45.0	67.5	22.5	45.0	22.5	22.5	22.5	45.0	472.5	247.5	405.0	157.5	22.5	0.0	45.0

In all these pots where the plants grew, the reaction of soil became acid, and where no growth of plants took place, the reaction turned to alkaline. The reaction of plant juice was slightly acid and it was not related to the reaction of soil. The nitrogen content was in proportion with the plant growth and a slight decrease was observed where no growth of plants took place.

The plants were examined for the weight of top and root, number of nodules formed and also the nitrogen content. The results are shown in Table IV :

Table IV.
Nitrogen Contents of Top and Root of *Astragalus sinicus*.

No. of Pots.	Series.	Top.			Root.				T. N. of whole Plant in one Pot.
		Wt. of crop. g.	% N	T. N. per pot. mg.	No. of nodules.	Wt. of crop. g.	% T. N.	T. N. per pot. mg.	
4	A	13.0	3.714	482.820	7	1.0	2.807	28.070	510.890
	B	17.0	3.527	599.590	14	1.5	2.839	42.585	642.175
5	A	16.0	3.800	608.000	24	2.0	2.429	48.580	656.580
	B	18.0	3.346	602.280	28	3.0	2.096	89.880	692.160
6	A	17.5	3.892	681.100	253	4.0	3.014	120.560	801.660
	B	35.0	3.868	1353.800	336	8.0	2.901	232.080	1585.880
7	A	26.0	3.804	989.040	581	6.0	2.742	164.520	1153.560
	B	18.0	3.862	695.160	214	5.0	2.788	139.400	834.560
8	A	5.5	2.753	206.415	118	1.5	2.646	396.690	246.105
	B	13.0	3.829	497.770	114	4.0	2.842	113.680	611.450

Table IV indicates that no appreciable difference in nitrogen content was found among the pots but where the better growth of plants took place, a slightly more nitrogen was found. The nitrogen content was greatest in Pot 6B followed by Pot 7A. In Pot 7A, 581 nodules were found while only 7 nodules in Pot 4A, and as a whole the number of nodules was in proportion with the growth condition. The size of nodules were in proportion with the plant growth viz. better the growth, the nodules were larger.

Summary and Conclusions.

This investigation was primarily intended to determine the relation between the soil reaction and the growth of *Astragalus sinicus* but the buffer capacity of soil was determined as well. The results may be summarized as follows :

1) As to the buffer capacity of soil from the paddy-field and dry-farm, there was no appreciable difference. The buffer capacity on the alkaline side was found to be slightly stronger in case of the latter and it was reversed on the acid side.

2) For germination of seed, P_H 5.6 was found to be the optimum, and for the growth, P_H 6.0 was the best. The limits for germination of seed were P_H 4.21 and P_H 7.90 respectively.

3) Better the growth of *Astragalus sinicus*, more nodules were formed and contained more nitrogen.

4) In the soils where the growth took place, the reaction became acid while in other soils without the plant growth, the acid changed to alkaline and vice versa.

5) No definite relation was found between the reaction of soils and that of the plant juice.

6) The nitrogen content of soil was increased by cultivating *Astragalus sinicus* and the rate of increase was in proportion with the growth of the plants.

7) The top of *Astragalus sinicus* contained more nitrogen than the root portion.

References :

- 1) A. ITANO and S. ARAKAWA, Hydrogen Ion Concentration of arable Japanese Soils. Noga-ku Kenkiu, 17: 93—117, 1931; A. ITANO, S. ARAKAWA and A. MATSUURA, Ibid: 118—124, 1931.
 - 2) A. ITANO and A. MATSUURA, Studies on Nodule Bacteria. I. Physiologicol Study. Noga-ku Kenkiu, 14: 432—448, 1930.
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PLATE XXXXII.

Growth, 81 Days after Planting.

