

The Agricultural Geography of the Nasu-Fan District, Tochigi Prefecture (8)

— Soil pH and barley in dried paddy field¹⁾ —

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Barley in dried paddy field of the Nasu-fan district is treated in the preceding paper³⁾, leaving its relation to soil as an unsettled question. The relation between soil pH and barley in dried paddy field, an investigation from the geographical point of view, is the problem at issue in this paper.

I. Soil pH values, in particular, their areal differentiations.

Samples of surface soils of paddy and upland field are collected at 2-5 cm depth from the ground surface. The collecting points are determined in reference to the intersecting points of quadrate meshes previously prepared on the topographical maps 1:50000 of the Geographical Survey Institute, covering the whole area of the Nasu-fan district. The meshes are consisted of rectilinear lines forming squares of equal dimensions, i.e. 1.2×1.2 cm² on the maps, or 600×600 m² in area on the spot. A group of lines are settled so as to run towards the direction of the slope of the fan, to which the other group are drawn to intersect at right angle. When no cultivated field is found at a certain intersecting point, paddy or upland field nearest to the point is selected in return. In this way, 440 soil samples are collected; of which 278 from upland field in Aug. 1951, and 162 from paddy field in Dec. 1952.

After the soil samples are air-dried, they are extracted with KCl solution (1N, pH 7.0) and pH values are determined by colour method using universal indicator. Accordingly, the pH of the paddy field soils show the values under drained conditions. On the whole, pH values of both paddy field soils and upland field soils range between 4.2 and 5.6; they are rather highly acid in a word.

- 1) Contribution from Department of Geography, Faculty of Literature and Education, Ochanomizu University, No. 5.
- 2) Jiyu-Gakuen
- 3) Matsui, I.: The Agricultural Geography of the Nasu-Fan District (4). Cropping Systems (1). Bulletin of the Geographical Institute, Tokyo University. 2 (1952), 35-53.

The frequency distribution of pH values of the paddy field soils, however, is considerably different from that of the upland field soils. Although nearly 90 per cent of the former concentrates upon the

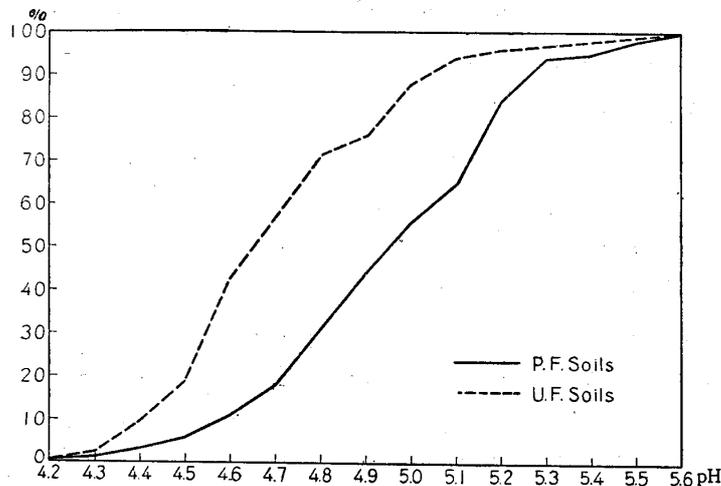


Fig. 1. The pH (using KCl Solution) of the Paddy Field Soils and the Upland Field Soils. —Total Area—

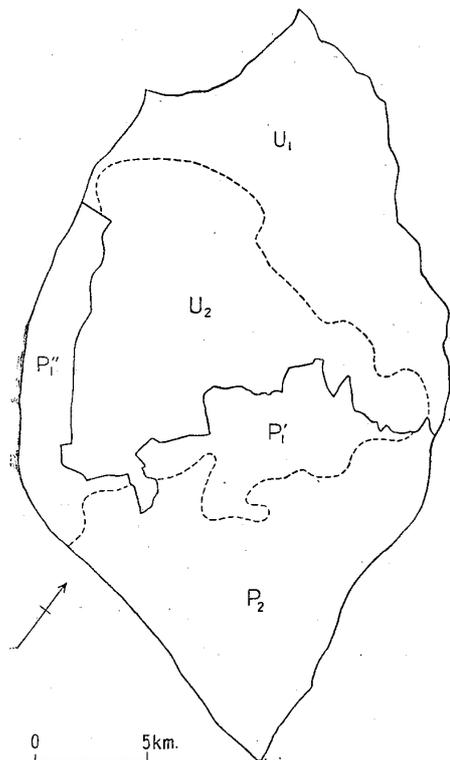


Fig. 2. The Division of the Nasu-Fan District, from the Distribution of the pH Values —using KCl Solution— of the Paddy and Upland Field Soils.

values of 4.6–5.3, and with other values only as exceptional, whereas for the latter the same 90 per cent concentration goes around 4.4–5.1. ⁴⁾ The cumulative frequency curves (Fig. 1) indicate that the upland field soils with pH value of 4.7 and the less are amounting to some 60 per cent of the whole, while for the paddy field soils those

characterized with the same values occupy only less than 20 per cent of all. Thus, the upland field soils, in general, are more acid than the paddy field soils.

Mention must be made in this connection that, in view of the fact that the paddy field soils belong practically and almost exclusively to the paddy field section P, the paddy field soils of the upland field section U are omitted, in the following discussions. As for the P section the subsection P₁, i.e. the region including P₁' and P₁'' in Fig. 2, is characterized with the paddy field soils bringing pH values of less than 4.9 with rare exceptions (Fig. 3). In the remaining subsection P₂, the pH are generally over 5.0 (Fig. 3), and those values 4.9 and the less are distributed regionally in isolation or forming only small areal groups. Accordingly, the section P is divided into two

4) With the exception of Figs. 2 and 12, Figs. 1–16 are representing the cumulative frequency curves, regarding the soil pH values.

subsections P_1 and P_2 , which differ each other as to the pH value of the paddy field soils.

With respect to the pH of the upland field soils, a region occupying the head area of the fan and being characterized with values 4.8 and the more is distinguished from the remaining region. The former belongs almost to the section U, with the exception of the small area which lies in the section P. Hereinafter, this area which belongs to the U section as above is indicated by U_1 , and the remaining part of the U by U_2 (Fig. 2). Concerning the pH as a whole of the upland field soils, a remarkable difference is found between U_1 and the other part of the fan, i.e. $U_2 + P$. Whilst in the subsection U_1 the soils at pH 4.8 and upwards amount even so high a percentage as 90 per cent of the total (Fig. 4), in the remaining region U_1+P those of pH values 4.8 and the less cover 80 per cent of all. Except the central part of the U_1 subsection, no remarkable area with the pH

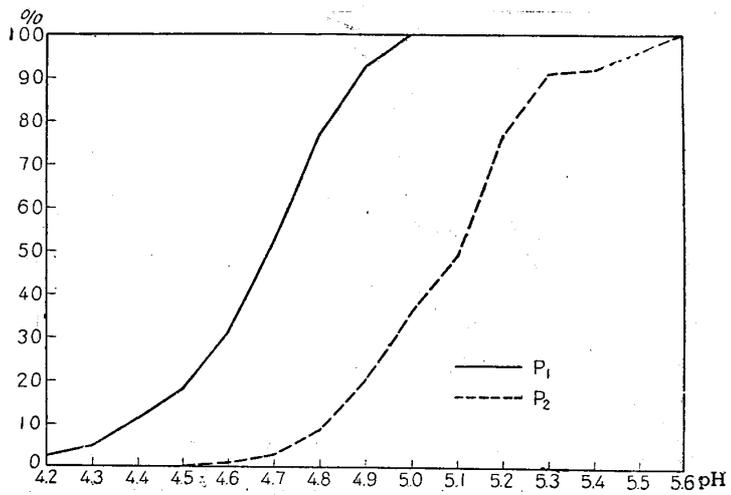


Fig. 3. The pH (using KCl Solution) of the Paddy Field Soils. —Sections P_1, P_2 —

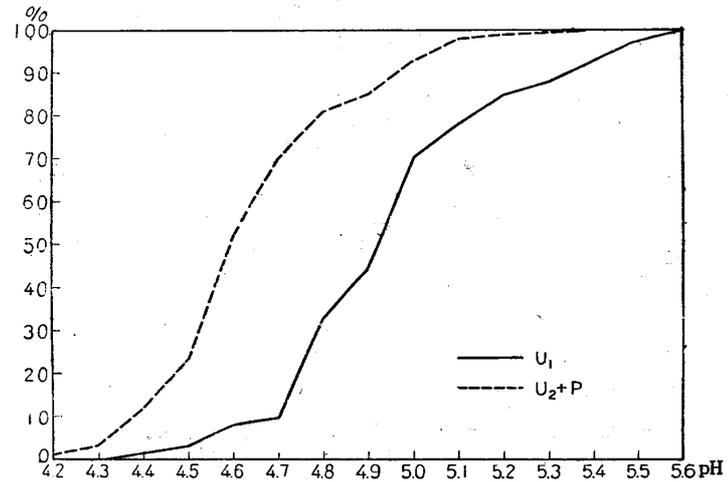


Fig. 4. The pH (using KCl Solution) of the Upland Field Soils. —Sections U_1, U_2+P —

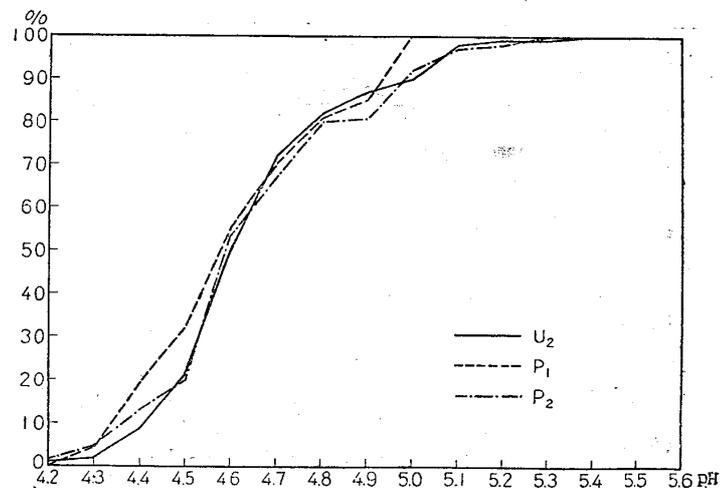


Fig. 5. The pH (using KCl Solution) of the Upland Field Soils. —Sections U_2, P_1, P_2 —

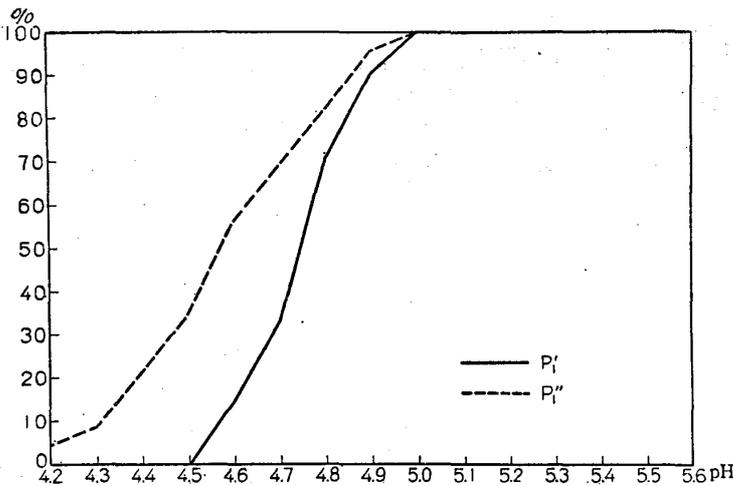


Fig. 6. The pH (using KCl Solution) of the Paddy Field Soils. —Sections P₁', P₁''—

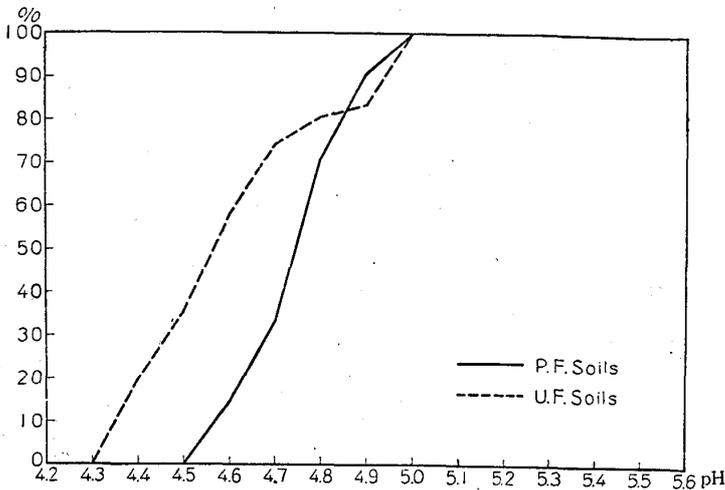


Fig. 7. The pH (using KCl Solution) of the Paddy Field Soils and the Upland Field Soils. —Section P₁'—

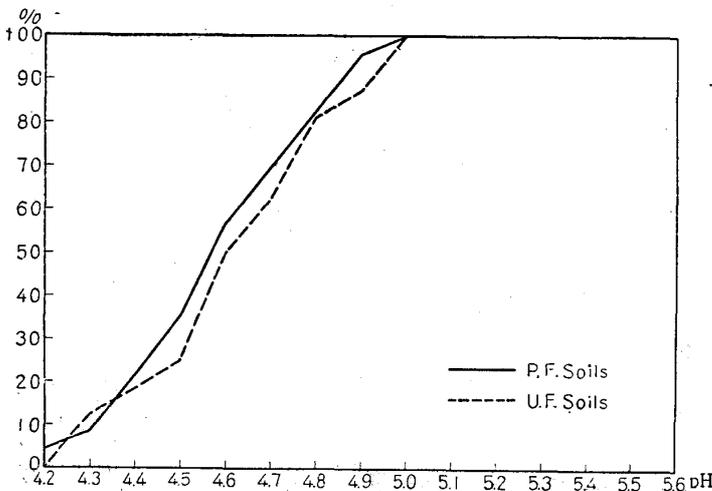


Fig. 8. The pH (using KCl Solution) of the Paddy Field Soils and the Upland Field Soils. —Section P₁''—

of its upland field soils 5.0 and upwards is found throughout the fan district.

In the region U₂+P, the pH of the upland field soils concentrates upon 4.6 and 4.7, other values being disseminated through the whole region making no large areal groups. Here the values are distributed regionally in marked confusion, that no distinct subsections can be contrasted each other regarding the pH. For instance, comparing the subsections U₂ and P, or even dividing the latter into P₁ and P₂, they are all characterized with rather equal frequency distribution of pH values (Fig. 5). Moreover P₁' and P₁'', which will be treated later, show frequency distribution of the same type (Figs. 7 and 8). Accordingly, viewing from the areal distribution regarding the pH of the upland field soils, the region U₂+P may be defined as a unit, and compared, as a whole, against the subsection U₁.

The subsection P₁₁ as distinguished from P₂ regarding the pH of the paddy field soils, is

composed of two parts P_1' and P_1'' being regionally separated each other (Fig. 2). Concerning pH values of the paddy field soils, however, P_1' and P_1'' are not identical. Although P_1' is characterized without exception with values 4.6 and the more, P_1'' comprises 4.5 and the less occupying one third of the total (Fig. 6). Moreover, in P_1' a considerable difference is found between pH values of the paddy field soils and those of the upland field soils (Fig. 7), while in P_1'' the pH of both soils are rather equal (Fig. 8), against which, concerning the subsection P_2 , the pH of the paddy field soils are exceedingly higher in value than those of the upland field soils, i.e., the values 5.0 and upwards for the former and 4.8 and the less for the latter do occupy respectively 80 per cent of the whole (Fig. 9). And pH of the paddy field show a considerably higher value, when compared with the pH of the upland field soils in U_1 as mentioned above. In U_1 over 70 per cent of

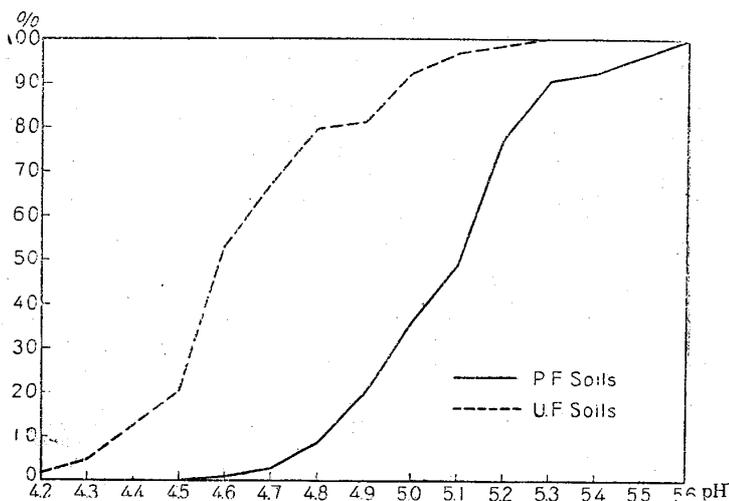


Fig. 9. The pH (using KCl Solution) of the Paddy Field Soils and the Upland Field Soils. —Section P_2 —

the upland field soils have the pH of 5.0 and the less, whereas in P_2 only one-third of the total paddy field soils gives the same values (Figs. 3 and 4). The paddy field soils in P_1' , however, show the pH markedly lower than those of the upland field soils in U_1 (Figs. 4 and 6).

In short, the soils of the cultivated field in the Nasu-fan district are highly acid in general. And, regarding their acidity, certain contrasts are distinctively formed according to regions above stated on one hand, and on the other hand, according to the soils whether they are from the paddy field or from the upland field. Generally speaking, the paddy field soils in P_2 give the highest pH values, followed by the upland field soils in U_1 as the second highest. The upland field soils in U_2 , P_1' , P_1'' and P_2 , together with the paddy field soils in P_1'' show about the same value in pH, with the lowest value throughout the fan district. Compared with these soils, pH values of the paddy field soils in P_1' are rather higher. The latter, however, are still markedly lower than those values given by the paddy field soils in P_2 and the upland field soils in U_1 .

A similar result can be drawn from a report⁵⁾ on a soil survey,

5) Results of the survey upon the acid soils in Tochigi Prefecture. 1949.

carried out by the Agricultural Experiment Station of Tochigi Prefecture. In this survey, samples of surface soils are collected from cultivated field, corresponding to the intersecting points of approximately quadrate meshes, established on the 1:50000 topographical maps of the Geographical Survey Institute. The meshes are drawn by dividing the length and the width of each map sheet into 29 and 35 equal length respectively; the real dimension of each quadrate is about 640×640 m². When no cultivated field is found at a certain intersecting point, an adequate field is selected within a distance of about 100 m from that point. In this case, paddy field soils are collected when and where the paddy field is dominant in the surroundings of the intersecting point, and upland field soils when and where the upland field is dominant. The collections of soil samples are practised in each autumn of 1948 and 1949. Thus 284 samples are collected from cultivated field on the fan district, of which 121 represents the paddy field soils and 163 the upland field soils.

The samples are air-dried, suspended with distilled water and the pH are determined by quinhydrone electrode method. The values of paddy field soils range from 4.6 to 6.3, and those of upland field soils from 4.4 to 6.3. The former, however, concentrate upon 4.9-5.5, and

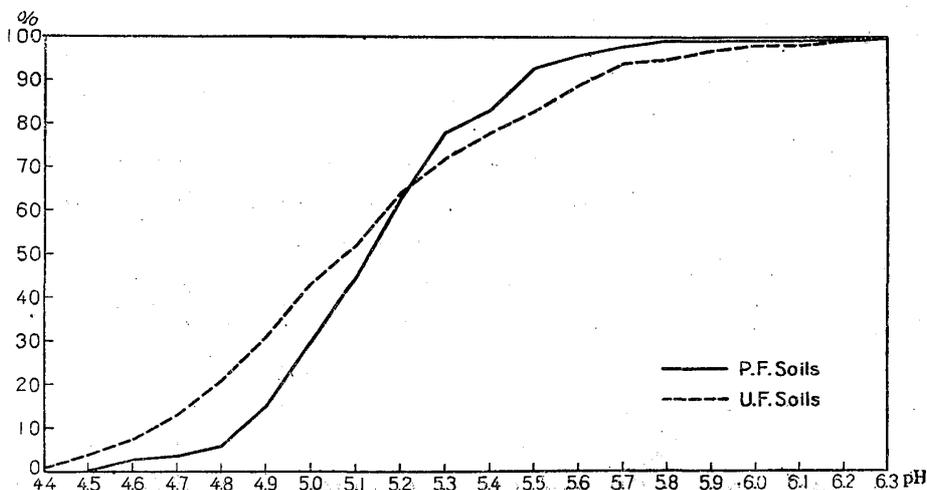


Fig. 10. The pH (using H₂O) of the Paddy Field Soils and the Upland Field Soils. —Total Area—

the latter upon 4.7-5.7, each amounting to 90 per cent of the whole respectively. As indicated by these values and also by cumulative frequency curves (Fig. 10), the pH in these cases are apparently higher than in those determined by colour method as stated above. The difference may be caused by the kind of the solvent used in extracting the soils, i.e. H₂O for the present and KCl solution for the preceding analysis. As far as the use of H₂O is concerned, the fan district as a

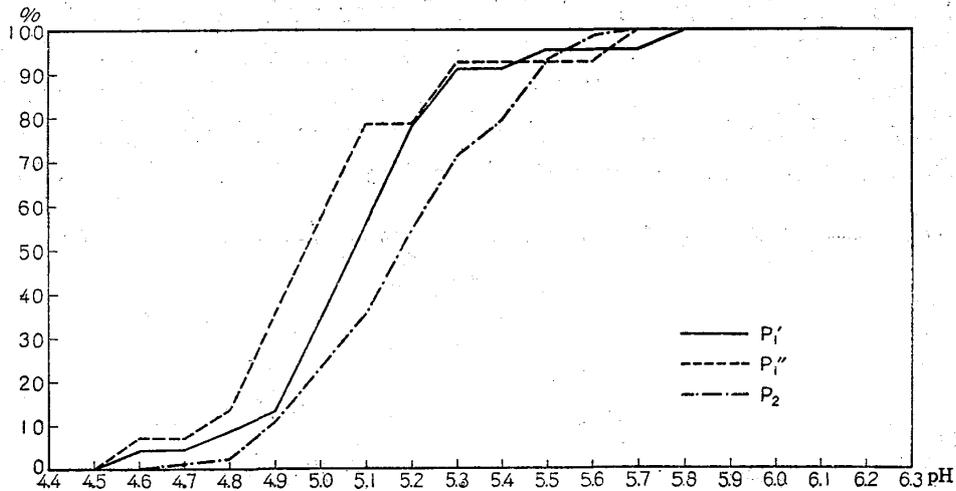


Fig. 11. The pH (using H₂O) of the Paddy Field Soils.
—Sections P₁', P₁'', P₂—

whole represents no marked contrast, between pH values of the paddy field soils and those of the upland field soils.

The paddy field soils belong almost exclusively to the paddy field section P, showing no remarkable areal differentiations in pH values.

In close observation in details, however, there is stretching in the center of the section a zone of rather low pH toward the direction of the fan slope. Moreover the contrasts corresponding to those concerning P₁', P₁' and P₂ as above mentioned are also clearly indicated. In P₁' the ratio of about 80 and in P₁' the ratio of 60 per cent, against the total are occupied respectively by pH values of 5.1 and the less, while in P₂, the corresponding ratio given by those values remains almost one-third of the total (Fig. 11). The pH becomes higher in order of P₁'', P₁' and P₂, as in the case of the colour method; the differences of the values among them are, however, not so remarkable.

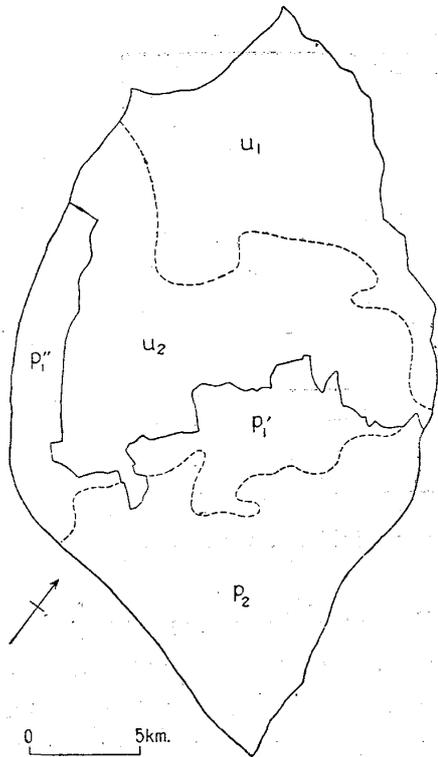


Fig. 12. The Division of the Nasu-Fan District, from the Distribution of the pH Values —using H₂O— of the Paddy and Upland Field Soils.

The upland field shows conspicuous areal differentiation of its soil pH, i.e. values in the head region of the fan being distinctly higher, compared with those of the remaining area. Such differentiation is explained in Fig. 12, in which u₁ represents the head region

giving the pH the value of 5.5 and over and belongs to the upland field section U, whereas u_2 shows the remaining part of the U section, and P_1' , P_1'' , P_2 indicate the above mentioned subsections of the paddy field section P. Against u_1 , almost all the remaining fan district, i.e. $u_2 + P$, is characterized by the pH 5.5 and the less (Fig. 13).

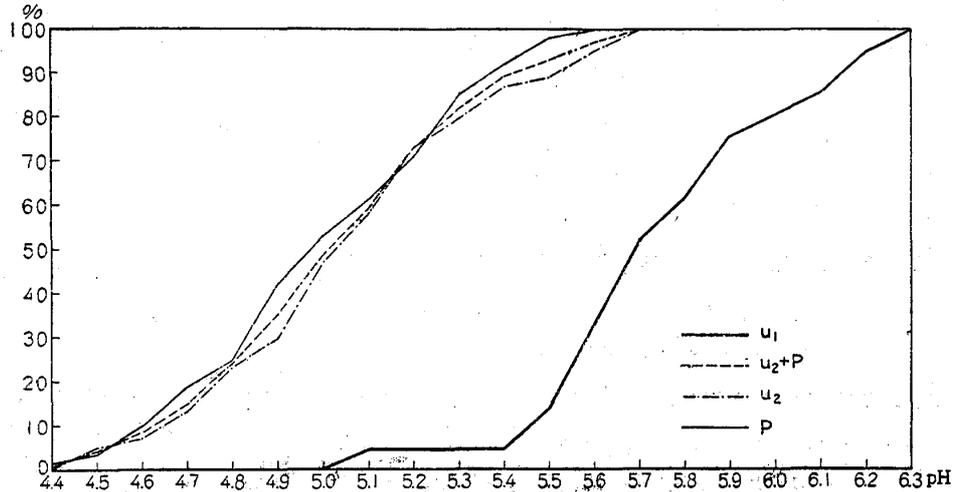


Fig. 13. The pH (using H_2O) of the Upland Field Soils.
—Sections u_1 , $u_2 + P$, u_2 , P —

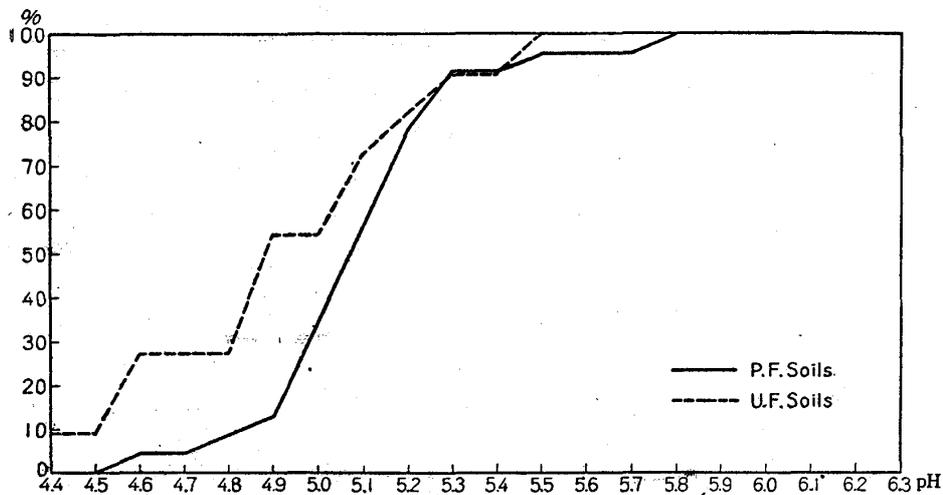


Fig. 14. The pH (using H_2O) of the Paddy Field Soils and the Upland Field Soils. —Section P_1' —

In the latter, however, certain regional differentiations are recognized, e.g. a zone showing rather higher pH extends from the central part to the terminal area of the fan in E-W direction. Here in the present paper, disregarding of this higher zone — which may be treated on another occasion if necessary — the area except u_1 is divided into u_2 and P , with the result that the frequency distributions of pH values are rather identical in the two sections (Fig. 13).

The respective relation between the pH of the paddy field soils and those of the upland field soils in P_1' , P_1'' and P_2 resembles rather

to what is obtained by the colour method for these subsections. In P_1' and P_2 , pH values of the paddy field soils are higher than those of the upland field soils (Figs. 14 and 15), the differences remaining at most

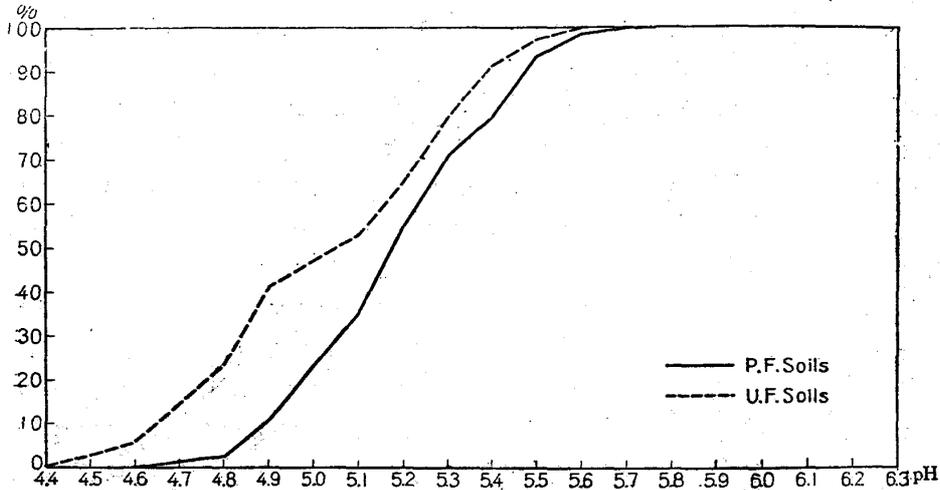


Fig. 15. The pH (using H_2O) of the Paddy Field Soils and the Upland Field Soils. —Section P_2 —

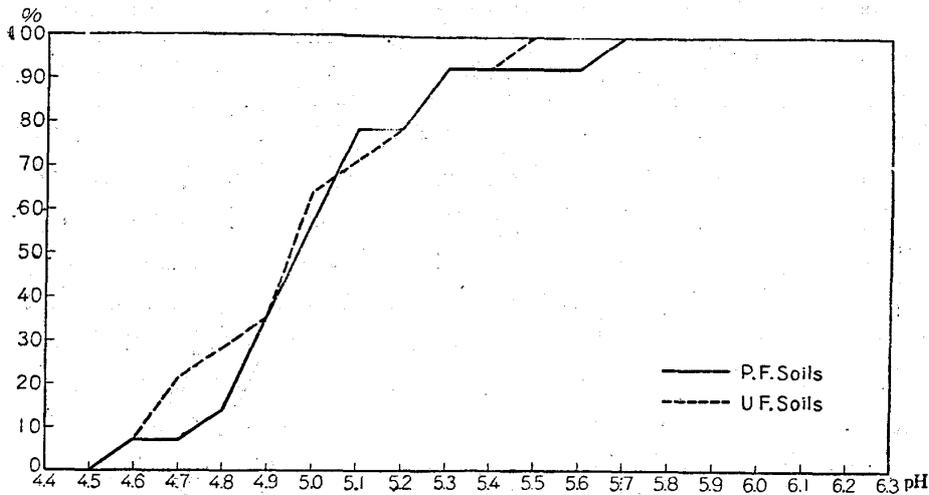


Fig. 16. The pH (using H_2O) of the Paddy Field Soils and the Upland Field Soils. —Section P_1'' —

as great as those indicated by the colour method for P_1' . Concerning P_1'' , the paddy field soils and the upland field soils represent approximately the same pH values each other (Fig. 16), as shown by the colour method.

Compared with the pH of the upland field soils in u_1 , values concerning the paddy field soils in P_1' , P_1'' , and even P_2 are markedly lower, giving generally 5.5 and the less (Figs. 11 and 13). As for the pH values, the upland field soils in u_1 are by far the highest, among the upland and the paddy field soils in the Nasu-fan district.

In short, judging from the soil pH of the cultivated field, the

Nasu-fan district indicates the following regional characteristics, irrespective of the difference lying in the two methods mentioned above.

- (1) The pH of the paddy field soils becomes lower in order of P_2 , P_1' and P_1'' .
- (2) Among the upland field soils, the highest pH value is given by those belonging to the head region of the fan, i.e. U_1 or u_1 , according to the colour or the quinhydrone electrode method respectively.
- (3) As for the pH values of the upland field soils, no difference is recognized in U_2 and P on one hand, nor in u_2 and P on the other.
- (4) The paddy field soils in P_1' and P_2 have pH values higher than those of the upland field soils in the same subsections; in P_1'' , however, values are rather identical for both soils.

By the colour method, the pH of the paddy field soils in P_2 reaches the highest, and the second place is given to the pH of the upland field soils in U_1 . Nevertheless, according to the quinhydrone electrode method, the upland field soils in u_1 give the highest pH, with no small difference from the second, namely, those of the paddy field soils in P_2 .

2. Soil pH, its relation to barley in dried paddy field.

Comparison among the subsections P_1' , P_1'' and P_2 .

According to the Agricultural Census in 1947, barley is dominant among crops cultivated in dried paddy field. In P as a whole, about 60 per cent of barley is allotted to dried paddy field. Concerning this ratio, however, remarkable differentiations are found among P_1' , P_1'' and P_2 ; in P_1' and P_1'' the ratios remain to be about 30 per cent respectively; in P_2 on the other hand, it approaches even to 75 per cent.

In P_2 the paddy field is much bigger in area than the upland field. While the average area of the latter per farm remains 5.7 tan⁶⁾, the former reaches 1.7 times as large. Accordingly the paddy field is drained and partly utilized for winter crops. As a matter of fact, by far the largest part of the upland field, during winter time, is under crops including wheat and barley as the leading ones, except and save the area reserved for potato to be planted in early spring of the succeeding year. In addition to this, at the same time, dried paddy field is, as a rule, utilized for growing up of these grain crops with the hope of realizing a bigger yield. Wheat and barley exceeding the quantity for each farmer's home use usually constitute an important source of his cash income, especially during summer season.

The acreage of these crops in dried paddy field is, however, limited to a degree, mainly because of the concentration of labour in the harvest season, which is especially brought about by the transplantation of young rice plant. Tobacco cultivation must be mentioned as well in this connection, especially if and when it is grown more or less

6) 1 tan = 0.25 acre

in large scale. As crop in dried paddy field, barley is preferable to wheat, since it is harvested earlier than wheat and can avoid the rush of the season in rice transplantation.

According to the questionnaire practised by the authors, area which suits for barley in the upland field is remarkably restricted. In general, the acreage yields of certain varieties of barley grown in upland field are considerably lower than those of the same varieties in dried paddy field, though better soils are selected. Consequently, barley is practically limited for dried paddy field crop, except where it is planted as a forerunner to tobacco in rotation of crop.

One of the factors determining such difference in acreage yields of barley, is perhaps the above mentioned difference in the soil pH of paddy field and of upland field (Figs. 9 and 15). As compared with wheat, barley is, as a rule, vulnerable than wheat to acid soils, being easily subject to soluble alumina, which again generally increases when the soil pH decreases. In view of these points together with the above area proportion between paddy and upland fields, it is not unreasonable to estimate that the soils suitable for barley cover far more bigger area in paddy field than in upland field, even though drainless areas are excluded.

In a word, smaller acreage of upland field per farm, the existence in bigger area of soils suitable for barley in paddy than in upland fields, and the last but not the least, the preferability of barley to wheat for the succeeding crop of rice—these are the conditions that make barley in the subsection P_2 more important as the crop in dried paddy field, not as the one in upland field.

In P_1' as in P_2 , almost all the upland field is devoted to winter crops, and the cultivation of barley in dried paddy field is practised, in the same way, taking advantage of the soils generally better than those of the upland field. As already indicated, the pH values of the paddy field soils in P_1' are rather higher than those of the upland field soils (Figs. 7 and 14). In fact, here in this subsection also, the acreage yields of barley are as a rule greater in dried paddy field than in upland field. In P_1' , however, the conditions regarding barley in dried paddy field are somewhat different from those of the subsection P_2 .

First of all, in P_1' as compared with P_2 , the upland field per farm is larger not only in area itself, but also in the ratio of the upland field to the paddy field, because in P_1' the acreage of paddy and upland field per farm is a little less than 8 tan respectively. In brief, as for P_1' , the dried paddy field can be less used than in case of P_2 , so far as the upland field crops are concerned. Besides, in P_1' the plantation of tobacco reaches to such degree that it is about 2 tan per farm, i.e. bigger by 0.6 tan than in P_2 . It is natural that the acreage of barley

in upland field as rotation crop preceding to tobacco is increasing, keeping pace with the acreage of the latter.

In addition the labour concentration for tobacco plantation works more powerfully than in P_2 to reduce the acreage of barley in dried paddy field. In this respect, however, the decrease of the acreage of rice transplantation is a factor again acting in opposite direction. Thus, from those factors regarding barley in dried paddy field, it may presumably be conjectured as a conclusion that, in P_1' as compared with P_2 , a comparatively bigger area of the upland field than the dried paddy field and a bigger barley acreage as preceding crop to tobacco in the upland field are the factors which are decisive in reducing the above mentioned ratio in P_1' as compared with the one in P_2 .

Finally, in P_1'' the conditions concerning barley in dried paddy field are different in the southern and the northern parts of this subsection. In the former, perhaps some 40 per cent of barley is planted in dried paddy field, in the latter, on the other hand, the ratio remains to be only 20 per cent. No difference is found in the soil pH values of upland field and in paddy field in the subsection as a whole (Figs. 8 and 16). In the southern part, however, the values, especially the values obtained by KCl solution, are somewhat lower in upland field than in paddy field, and, in the northern part, the adverse conditions are prevailing. — As for the values obtained when distilled water is used, such areal contrast does not appear. — Speaking of average barley crop per tan, in the southern part, the acreage yields of barley in dried paddy field are generally greater than those in upland field, while in the northern part, there seems no conspicuous difference in the yields of these two kinds of field.

Again in the northern part, lesser ratio in barley acreage in dried paddy field is witnessed, whilst the fact is that the paddy field has two times as large an area as that of the upland field per farm which is reported to be of only 4 tan. This is solely due to the single fact that the transplantation of young rice plant must be carried out comparatively earlier in season, and in a short elapse of the season. The climate is presumably a determining factor in the present case. The tobacco planting on a smaller scale as compared even with P_2 , and the above mentioned soil pH conditions, are considered as only secondary factors.

Regarding the southern part, the insufficiency of data prevents the authors from discussing the problem in details.

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