Butler University Botanical Studies

Volume 2 *Butler University Botanical Studies* Article 9

The Value of Rumex Acetosella as an Acid Indicator

Russell Artist
Butler University

THE VALUE OF RUMEX ACETOSELLA AS AN ACID INDICATOR

By RUSSELL C. ARTIST

Among laymen and agriculturists it is a common expression that certain spots in a field are acid. The term "acid spots" has come to be used more and more since soil reaction has been shown to have some bearing upon the soil preferences of many plants. That there is a correlation between the hydrogen-ion concentration of the soil and natural plant distribution has also been shown by a number of writers (6, 9, 14, 15). *Rumex acetosella* has been considered to be an acid indicator (1, 5). The purpose of this paper is to determine if there is a consistent correlation between the hydrogen-ion concentration of the soil and the distribution of a native species.

METHODS

The habit of the plant of growing in distinct clumps in practically every waste field has been the basis for the singling out of three different positions in and immediately surrounding each clump of plants. These positions have arbitrarily been called center, margin and outside. The center refers to the organic center of the clump, where the plants seem to attain their most luxuriant growth, both in numbers and size; the margin is construed to mean the point at which the plants tend to become less abundant and finally to drop out entirely, while the outside includes an area uninhabited by the plant in question, usually from fifteen to twenty-five feet from the center of the clump. Soil samples were taken from the surface and from a depth of three inches, this depth generally being sufficient to reach the fibrous root system of the plant. Each clump of plants comprised one station consisting of a series of five surface and five corresponding subsoil samples, two from the center, four from the margin and four from the outside position respectively. The stations were widely distributed among three counties in Indiana, as follows: Seven stations in the northwestern part of Brown county near Trevlac, thirteen stations in the central part of Montgomery county in a region known as Pine Hills, and ten stations in the central part of Marion county in Indianapolis. The soils were tested for their H-ion concentration with the Youden Hydrogen-ion concentration apparatus shortly after being brought into the laboratory, although Rost and Trieger (12), in a recent paper, showed that drying and storage have no effect upon pH of soil samples. Only one e.m.f. reading of the galvanometer needle was taken for each sample, since it was thought that a more accurate average might be obtained by testing a greater number of soil samples rather than by taking a series of three consecutive readings for a smaller number of soils as suggested in the work of Cain and Friesner (3). The results from thirty surface and thirty subsoils in the center, sixty surface and subsoils in the margin and a like number in the outside are given in Table I.

DISCUSSION

In recent years so much importance has been assigned to the chemical nature of the soil in controlling or influencing plant distribution, and such a vast amount of work has been done on the relation of soil reaction to natural distribution of plants, that a brief review might be well at this time. Berkman (2), summing up the work of the earlier workers, says that Moore and Taylor (9), in their observation on a marine bog, found that 25 per cent. of the components of the vegetation in the bog proper were of arctic alpine species. The pH value of the soil in this case ranged from 4.5 to 4.0, while on a rock ledge at the same place the pH value of the soil was 5.0 and only 6.3 per cent. of the plants here were of arctic alpine species. None of these species occurred in the surrounding timber, where the reaction of the soil was 6.0. Salisbury (13) observed that acid-loving plants were more frequent on ground where leaching was rapid, and that the valleys where alkaline substances collected after being leached from higher ground contained vegetation usually found in alkaline soils. Reed and Klugh (10), in their work on two pools located near each other, one a granite and the other a limestone pool, showed that each one had its own characteristic biota. Kelley (7) studied five different soil types and concluded that soil acidity is one of the ecological factors in plant growth. A study of the distribution of species around salt marshes led Wherry (20) to a similar conclusion. In a study of the oak-hornbeam woods of Hertfordshire, England, Salisbury (15) observed that *Holcus lanatus, Cnicus palustris* and *Anthantum odoratum,* all acid-loving species, invaded the coppiced areas. Analysis showed that these soils were much more acid than those from uncoppiced woods.

The more recent work of Kurz (8), however, presents a contrast to the preceding views, since he observed that some hitherto so-called acid soil plants were found growing in soils ranging from definite alkalinity to high acidity, and maintained that H-ion concentration in itself was not the main factor in determining the distribution of the species considered. Gustafson (6) seems to believe that the reason we find some plants growing and thriving in very acid soil might be that they have developed a protoplasm which is not injured by a high concentration of H-ions, but which is injured when the plants are grown in solutions or soils of low H-ion concentration. He offers a plausible explanation for the fact that there are more plants growing in soils having an acid reaction than in soils having an alkaline reaction by attributing it to the acid character of the protoplasm and cell sap of most plants. Geisler (4), working on the relation of soil reaction to plant succession in the Cincinnati region, found nothing to indicate that the soil reactions were responsible for species distribution in that region. Other factors, she contends, such as water content, may be enough to account for the distribution of many species, and the fact that a large number of species listed occur in only one or several closely related communities does not mean dependence of these plants upon H-ion or OH-ion concentration. Turner (17), working on the soil preferences of some seventy-five species of Compositæ in the Cayuga lake basin, found that one-fifth of the species observed tended to require acidity in their soil reaction, one-fifth was tolerant of both acid and alkaline soil reactions, and about three-fifths of the species required alkalinity in their soil reaction. The soil reaction for the species *Solidago arguta* was found to vary from year to year and from season to season. Three species were greatly reduced in vigor, in height and in the number of individual plants, when growing on soils of high acid or alkaline reaction. An investigation of the soil acidity of eastern Missouri led Steyermark (16) to the conclusion that in some cases the distribution of certain plants is affected by the soil acidity. In some cases this soil acidity can be traced back to the water relationship in the soil and in some cases it can not. Robinove and La Rue (11) reported that of thirty-three species of pteridophytes and about one hundred species of bryophytes of the Douglas lake region, many of the plants can tolerate a wide range of soil reactions. They found that almost all of the species for which a considerable number of determinations were secured varied greatly in the pH values of the substratum.

RESULTS

In the present paper, all attempts to correlate H-ion concentration of the soil with distribution of *Rumex acetosella* yield only negative results. Wherry (18) states that H-ion concentration of the soil is hut one of the factors concerned in determining whether a given plant may grow in a certain place. If the plant here studied were an acid-loving species, a condition of decreasing acidity progressing from the center of a particular clump to the outside would seem to be the expected result, since the greatest abundance of the plants in the center should he correlated with a higher concentration of H-ions. Similarly, a relatively smaller number of plants in the margin should be correlated with less acid reaction, and the total absence of the plant in the outside should he correlated with a still lower acid reaction of soil. It is interesting to note, however, that of the thirty stations listed in Table I, the surface soils of twelve of these stations show a decrease in acidity from the center of the clump to the outside; at nine stations there is shown to be an increase in acidity from the center of the clump to the outside; while nine stations show no consistent or progressive increase or decrease in acidity.

Of the twelve stations showing a trend toward a decrease in acidity from center outward, eight show marginal soil to he more acid than the soil outside the clump, while four show marginal soil to be less acid than soil outside the clump. Of the nine stations showing a trend toward an increase in acidity from the center outward, seven show the marginal soil to be more acid than that outside the clump, while two show the marginal soil to be less acid than that outside the clump.

The subsoils of five of the thirty stations show a decrease in acidity from center of clumps outward, three show an increase and twenty-two show such a wide range of fluctuation that no definite trend toward acidity or alkalinity can be assigned them. There is a greater degree of consistency in the suhsoils in the few stations which tend toward an acid or alkaline reaction. All of the five stations showing a decrease in acidity were consistent, and, of the three stations showing an increase, in only one was there a greater increase in the margin than in the outside.

The range of pH for all surface soils of center, margin and outside was from pH 4.7 to 6.5, 4.8 to 8.1 and 4.5 to 7.7, respectively. The subsoils showed a lower range as follows: 4.4 to 6.3, 4.5 to 7.3 and 4.4 to 7.7, respectively. It is to be seen here that the pH range of the center of the clumps is less extensive than the range shown by the margins or outsides.

Figure 1 gives a graphic summation of the foregoing tables. The percentage of all surface and subsoil samples taken in each of the three positions at all stations is shown at each pH range. The peak in per cent. of samples for center and margin is reached in pH range 5.0 to 5.5, the center having 33 per cent. and the margin 43 per cent. of all determinations between these pH values. The peak for the outside position, however, is reached in pH range 5.5 to 6.0 with 35 per cent. of the total readings.

In the subsoils, the peak for center and outside falls in the pH range 5.0 to 5.5, the center having 40 per cent. and the outside 42 per cent. of all determinations between these pH values, but the margin reaches its peak in pH range 5.5 to 6.0, as was the case for the outside in the surface soils. The greater per cent. of readings (subsoil) of the outside occurring in pH range 5.0 to 5.5, and the occurrence of 36 per cent. of the readings of the margin in pH range 5.5 to 6.0, present a striking contrast to these positions in the surface soils. In Figure 1 it will be seen that in the different pH ranges there is no consistent relation between center, margin and outside, whereas, if *Rumex acetosella* were an acid indicator, the center position should show a higher per cent. of its determinations in lower pH range than should the margin and outside.

Figure 2 shows curves for surface and subsoils in ten typical stations and a final curve for the average of all stations. Here, also, there is shown to be a lack of a consistent decrease in acidity from center to outside, since it can readily be seen that only two stations show the same general trend toward decreased acidity, while the remaining eight have nothing in common in any respect. Both surface and subsoils in these eight stations show practically the same amount of fluctuation as the curve progresses from center to outside. The fact that the soils collected were of several different types might seem to present a factor for error, but a series of curves (not shown herewith) drawn for the stations occurring in the three general types of soil, namely, clay, loam and sandy-clay, shows the same general lack of consistency in relation of reaction to position, even for soils of the same general type. From a survey of the curves for the ten stations shown in Figure 2, it becomes obvious that an analysis of stations 14 and 27, which show a trend toward decreasing acidity from center outward, would give widely differ-

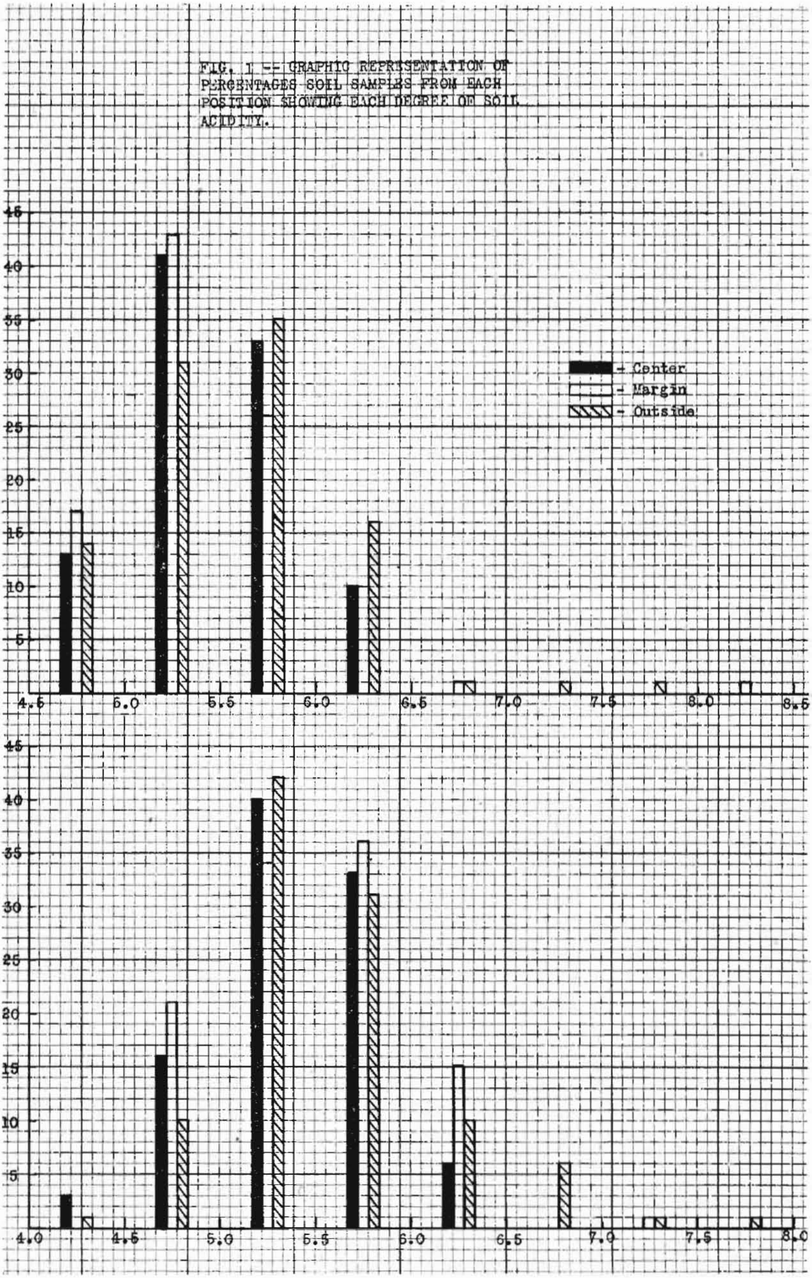
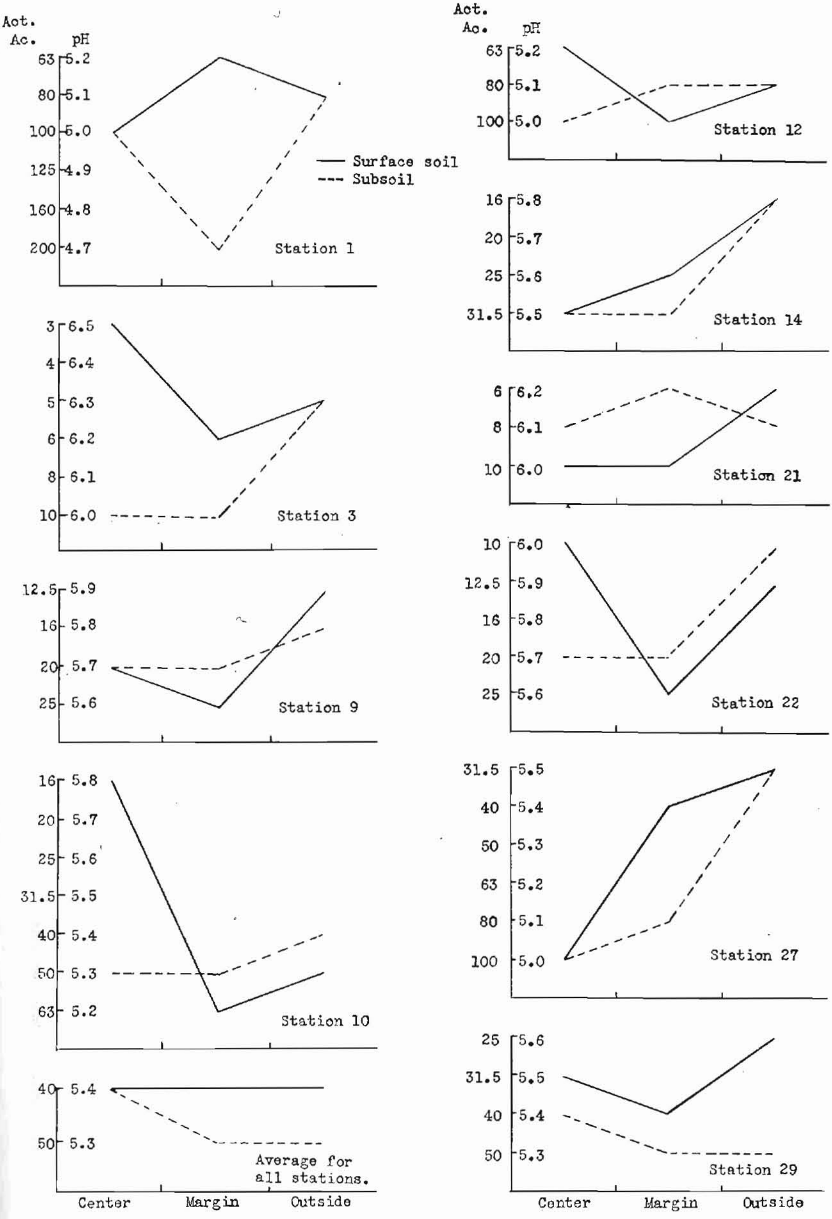


FIG. 1 -- GRAPHIC REPRESENTATION OF PERCENTAGES SOIL SAMPLES FROM EACH POSITION SHOWING EACH DEGREE OF SOIL ACIDITY.

FIGURE 2. Ph AND ACTIVE ACIDITY OF CENTER, MARGIN AND OUTSIDE POSITIONS FOR TEN STATIONS, WITH FINAL CURVE SHOWING AVERAGE OF ALL STATIONS



ent results than an analysis of the remaining eight stations, which show a large amount of fluctuation in reaction. This is brought out well, it seems, in the curve expressing the averages for all stations, the pH values being averaged according to Wherry (19). The curve for the surface soils is a straight line, while that for the subsoils indicates a higher acid reaction in the outside than in either center or margin.

These results check very closely with those of Steyermark (16), who contends that a multiciplicy of factors in certain combinations or ratios have much to do with affecting the distribution of a plant, rather than any single factor, such as that of soil acidity. It is here also shown that the species studied seems to be indifferent toward H-ion concentration of the soil and will accept a rather wide range of soil reaction. In the opinion of the writer, a more detailed analysis of the soil, both physical and chemical, including such factors as colloidal constituents and characteristics, mineral constituents, porocity and water content, is necessary to an accurate determination of the relative soil reactions of soil samples. The results presented herewith seem to indicate that the so-called "acid spots," as indicated by the presence of *Rumex acetosella,* in fields are not always acid, and that if there exists a definite correlation between soil reaction and distribution it is not consistent when a large number of stations is considered.

SUMMARY

1. *Rumex acetosella,* a so-called acid soil plant, was found growing in soils showing a reaction well toward the neutral point and in soils showing a definite alkaline reaction, *viz.,* pH 6.3 and 7.6 respectively.

2. The range of pH for all surface soil samples was from pH 4.5 to 8.5. The range of pH for all subsoil samples was from pH 4.0 to 8.0.

3. For all samples the average reaction for surface soils of center, margin and outside was 5.4, 5.4 and 5.4, respectively, and for subsoils was 5.3, 5.3 and 5.4.

4. From the data thus far collected, it seems that *Rumex acetosella* has no value as an acid indicator.

The writer takes this opportunity to express his appreciation to Dr. Ray C. Friesner for suggesting this problem and also for much helpful criticism offered during the process of this study.

TABLE I. AVERAGE ACTIVE ACIDITY AND pH FIGURES FOR THE THREE POSITIONS, CENTER, MARGIN AND OUTSIDE, OF THIRTY STATIONS

AVERAGE ACTIVE ACIDITY AND pH

	Surface Soils			Subsoils		
Station	Center	Margin	Outside	Center	Margin	Outside
1	5.0 (1)	5.2	5.1	5.0	4.7	5.1
	100.0 (2)	70.00	90.0	100.0	220.0	75.0
2	5.8	7.6	6.2	5.8	6.3	6.6
	16.0	—4.5	5.7	16.0	5.5	2.2
3	6.5	6.2	6.3	6.0	6.0	6.3
	3.0	6.5	5.5	10.0	10.0	5.5
4	5.6	5.5	6.4	5.3	4.8	5.3
	25.0	30.0	4.5	50.0	30.0	3.0
5	6.2	5.3	5.5	5.3	4.8	5.3
	6.0	56.0	30.0	50.0	150.0	47.2
6	4.7	5.1	5.7	4.8	5.3	5.7
	200.0	81.0	18.7	160.0	55.7	20.5
7	5.4	5.8	6.5	6.3	6.3	5.4
	16.0	3.0	41.5	5.0	5.5	37.7
8	5.3	5.5	5.9	5.2	5.3	5.8
	50.0	31.5	12.0	63.0	55.7	15.0
9	5.6	5.5	5.8	5.6	5.6	5.7
	25.0	35.7	16.2	25.0	25.0	20.7
10	5.8	5.2	5.3	5.2	5.2	5.4
	16.0	77.0	70.0	63.0	70.0	40.7
11	4.8	5.1	4.9	5.0	5.0	4.7
	160.0	90.0	130.0	100.0	120.0	231.0
12	5.2	5.0	5.1	5.0	5.1	5.1
	63.0	100.0	90.0	100.0	81.0	81.0
13	5.4	6.0	5.5	5.6	5.6	5.5
	40.0	10.5	30.0	25.0	25.0	31.5
14	5.5	5.6	5.8	5.5	5.5	5.8
	31.5	27.0	16.0	31.5	28.2	17.5
15	5.5	5.5	5.6	5.5	5.5	5.4
	31.5	28.0	23.7	31.5	31.5	37.0
16	5.3	5.6	5.8	6.0	5.5	5.9
	50.0	25.7	15.0	10.0	31.5	12.7
17	5.5	5.6	5.5	5.7	5.8	5.2
	31.5	25.7	32.0	20.0	32.0	62.0
18	5.2	5.4	5.7	5.4	5.5	5.4
	63.0	40.7	20.2	40.0	32.0	44.0
19	5.5	5.7	6.5	5.6	5.9	6.1
	31.5	20.2	3.7	25.0	13.0	9.0

(1) pH values; (2) average active acidity.

	Surface Soils			Subsoils		
Station	Center	Margin	Outside	Center	Margin	Outside
20	6.2	6.1	6.2	6.0	5.9	6.3
	6.0	9.0	7.0	10.0	13.0	5.0
21	6.0	6.0	6.2	6.1	6.2	6.1
	10.0	10.0	7.0	8.0	76.0	8.0
22	6.0	5.6	5.9	5.7	5.7	6.0
	10.0	25.0	13.0	20.0	20.0	10.0
23	6.0	6.1	5.7	6.0	5.8	5.3
	10.0	7.5	19.7	10.0	15.0	56.2
24	5.4	5.1	5.2	5.3	4.8	5.3
	40.0	81.0	65.0	50.0	160.0	48.0
25	5.3	5.1	4.8	4.4	5.0	5.3
	50.0	87.0	162.0	400.0	112.0	56.0
26	5.8	5.3	5.2	5.4	4.8	5.3
	16.0	56.0	71.0	40.0	150.0	70.0
27	5.0	5.1	5.5	5.0	5.4	5.5
	100.0	81.0	33.0	100.0	45.0	31.5
28	5.3	5.2	5.2	5.3	5.5	5.5
	50.0	70.0	70.0	50.0	35.0	31.5
29	5.5	5.4	5.6	5.4	5.3	5.3
	31.5	39.0	25.7	40.0	47.2	55.2
30	5.6	5.2	5.4	5.5	5.0	5.0
	25.0	81.0	70.0	31.5	100.0	100.0

LITERATURE CITED

1. BERGEN, JOSEPH Y. Key and flora northern and central states. Ginn & Co., Boston. 1908. pp. 70.
2. BERKMAN, A. H. The pH values of some Texas soils and its relation to the incidence of certain woody species. Soil Sci. 25: 133-142. 1928.
3. CAIN, S. A., and R. C. FRIESNER. Certain aspects of the H-ion concentration of the soils of a central Indiana river bluff. Butler Univ. Bot. Stud. 1: 172-175. 1930.
4. GEISLER, S. Soil reactions in relation to plant succession in the Cincinnati region. Ecol. 7: 163-184. 1926.
5. GEORGIA, ADA. Manual of weeds. MacMillan Co., New York. 1927. pp. 95.
6. GUSTAFSON, F. Plant distribution as affected by the H-ion concentration of the soil. Mich. Acad. Sci., Arts and Let. 2: 237-245. 1926.
7. KELLEY, A. P. Soil acidity an ecological factor. Soil Sci. 16: 41-57. 1923.
8. KURZ, H. H-ion concentration in relation to ecological factors. Bot. Gaz. 76: 1-30. 1923.
9. MOORE, B., and N. TAYLOR. Plant composition and soil acidity of a Maine bog. Ecol. 2: 258-261. 1921.
10. REED, G., and A. B. KLUGH. Correlation between H-ion concentration and biota of granite and limestone pools. Jour. Ecol. 5: 83-117. 1918.
11. ROBINOVE, JOSEPH J., and CARL D. LA RUE. The hydrogen-ion concentration of the habitats of the Bryophytes and Pteridophytes of the Douglas lake region. Mich. Acad. Sci., Arts and Let. 9: 273-286. 1928.
12. ROST, C. O., and E. A. TRIEGER. The effect of drying and storage on the H-ion concentration of soil samples. Soil Sci. 16: 121-126. 1923.
13. SALISBURY, E. J. Stratification and H-ion concentration of the soil in relation to leaching and plant succession, with special reference to woodlands. Jour. Ecol. 9: 220-240. 1922.
14. —— The incidence of species in relation to soil reactions. Jour. Ecol. 13: 149-160. 1925.
15. —— The oak-hornbeam woods of Hertfordshire. Jour. Ecol. 4: 83-117. 1918.
16. STEYERMARK, J. A. A study of plant distribution in relation to the acidity of various soils in Missouri. Ann. Mo. Bot. Gard. 18: 41-55. 1931.
17. TURNER, A. J. The relation of the distribution of certain Compositæ to the H-ion concentration of the soil. Bull. Torr. Bot. Club 55: 199-213. 1928.
18. WHERRY, E. T. Soil acidity, its nature, measurement and relation to distribution. Ann. Rept. Smithsonian Institution, 1920. 247-268.
19. —— A new method of stating H-ion (Hydrion) concentration. Bull. Wagner Free Institute Sci. 2: 59-64. 1927.
20. —— Plant distribution around salt marshes. Ecol. 1: 42-48. 1920.