Differences Between Selected High and Low Ground Soils of Indiana[1]

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Abstract

High ground soils and adjacent upland depressional or low ground soils in the same field were compared. The plow layers of the low ground soils were higher in organic matter, extractable calcium and magnesium, and cation exchange capacity, than the high ground soils. Grain yields over a four-year period were significantly higher on low ground than on high ground soils. These higher yields were associated with earlier tasseling and silking, lower moisture percentage in the grain at harvest, taller plants in some cases, and a higher plant population in many comparisons. Total soil moisture by volume tended to be higher on the low ground soils. The hypothesis was advanced that, in these low ground soils, higher organic matter content may be important in reducing surface crusting and in increasing plant population.

Potential capacity of soils to produce crops at high levels of management can be estimated from their present crop yields, from their internal characteristics, from adjacent physiographic features, and from climate. Odell and Oschwald (7) have made estimations of crop yields of Illinois soils. Differences in Illinois soils with respect to rooting characteristics had previously been described by Fehrenbacher and Alexander (2). Similar publications estimating crop yields from Indiana soils have been prepared (4).

The purpose of this report is to supply additional information associating soil differences with corn performance. Many characteristics of soils are interrelated in their influence on crop performance. Specific cases will be mentioned.

Methods and Procedures

Five farms with high corn yields in the Indiana Five-Acre Corn Contest were selected for this study. On each farm two adjoining soils in the same field were chosen. On 3 of the farms the same soil locations were used all 4 years. On 2 farms, 2 different fields were used during the 4-year period.

The soils used in this study were primarily Alfisols (Gray-Brown Podzolic soils) on the upland high ground and Mollisols (Humic-Gley in this study) in adjacent upland depressional (low ground) areas. The two soils in the same field received the same production practices and management (*i.e.*, planting rate, date, hybrid, fertilization, weed control, etc.) and approximately the same rainfall, temperature, and sunlight. The farmer's name and location, soil types, important production practices, and July and August rainfall for each year are given in Table 1.

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TABLE 1. *Corn production information from cooperating farms having high-yielding soils, 1967-1970.*

Farmer and location in Indiana	High ground and low ground soil types	Year	Fertilizer applied annually N + P + K (kg/ha)	Corn hybrid	Planting date	Population (Plants/ha)	Rainfall (mm)	
							July	Aug.
H. McKowen	Crosby silt loam	1967	188 + 56 + 63	Dennis 12	May 22	47,611	47.8	11.2
Alexandria	Brookston silt loam	1968	123 + 37 + 102	Dennis 15	May 8	43,042	51.8	131.6
		1969	190 + 39 + 74	Dennis 14	May 15	43,131	102.1	116.1
		1970	230 + 49 + 93	Dennis 14	May 21	48,946	137.7	50.5
W. Franklin	Crosby silt loam	1967	241 + 29 + 56	Cargill 880	May 29	58,975	29.7	1.8
Jamestown	Ragsdale silty clay loam	1968	272 + 35 + 67	Northrup King 610	April 27	52,947	27.7	72.9
		1969	317 + 86 + 163	DeKalb XL66	May 2	65,818	115.8	103.4
		1970	277 + 94 + 397	Northrup King 610	May 5	62,949	64.5	41.7
L. Priebe Ladoga	Reesville silt loam	1967	224 + 45 + 112	Funks G4401	May 28	57,971	156.7	76.7
	Ragsdale silty clay loam	1968	158 + 18 + 33	Funks G4401	June 10	51,382	43.9	134.1
		1969	234 + 62 + 145	Waxy Maize 455	April 25	57,035	208.3	15.2
		1970	224 + 45 + 112	Pioneer 3369A	May 5	57,803	131.3	34.3
J. Bosstick Farmersburg	Iva silt loam Ragsdale silt loam	1967	307 + 10 + 312	Pfisters Associated Growers SX-29	May 24	64,246	84.1	62.0
		1968	230 + 49 + 232	DeKalb XL-66	June 9	53,775	86.2	52.6
		1969	213 + 49 + 279	DeKalb XL-66	May 6	58,920	140.0	54.9
		1970	281 + 39 + 9	Pioneer 3369A	May 10	65,453	48.3	50.8
E. Neyhouse	Reesville Silt loam	1967	291 + 92 + 189	Pioneer 3306	May 14	55,598	277.4	63.2
Princeton	Zipp silt loam	1968	282 + 95 + 176	Pioneer 3196	April 26	50,547	228.6	0.0
		1969	336 + 102 + 193	Pioneer 3369A	April 27	65,199	323.9	133.1
		1970	314 + 106 + 201	Pioneer 3369A	April 9	63,715	44.7	86.9

Descriptions of the soils listed in Table 1 were made by D. P. Franzmeier, A. L. Zachary, and P. W. Harlan (personal communications). Samples from all horizons of the 10 soils at selected locations were collected in 1967. Analyses of samples from the plow layers were made in 1970 by the Purdue Soil Testing Laboratory. Soil water pH and available P (Bray No. 1) were determined by procedures listed by Hood (3). Organic matter was determined using a modification of the Walkley-Black procedure reported by Jackson (5). Extractable bases were determined using a modification of the neutral normal ammonium acetate procedure used by the U. S. Department of Agriculture (9). Extractable acidity was determined using a modification of the triethanolamine method reported by Peech *et al.* (8). Cation exchange capacity was determined by addition of milliequivalents of calcium, magnesium, potassium, sodium, and hydrogen (extractable acidity). Base saturation percentages were obtained by dividing the sum of the extractable bases including sodium by the cation exchange capacity and multiplying by 100.

A nested design with five replications or sublocations was used for determining crop yields in each soil type. The diameter of the area sampled on each soil was 41 m (135 ft). The five harvested areas on each soil type were each two rows wide and 10.7 m (34.8 ft) long.

Crop yields were determined by hand harvesting ears, weighing these ears, determining moisture percentages in the grain, and calculating yields using Remmenga's tables of pounds of ears required for a bushel of 15.5% moisture shelled corn. These tables were contained in Brunson's Purdue Agricultural Extension Circular 472 (1). Each fourth ear was harvested, and all ears and barren stalks were counted.

Grain moisture percentages were determined using shelled grain from 10 or more ears from each replication. Shelled grain was weighed, dried at 100 to 105°C for 24 to 30 hours, weighed again, and percentage of moisture calculated.

Soil moisture measurements were made with a Troxler neutron probe and scaler. The source of neutrons was Americium and Beryllium. Principles explained by C. H. M. Van Bavel (10) were used by D. Wiersma to calibrate this probe. On the Priebe and the Franklin Farms, three replications of neutron probe access pipes on each soil type were used. On the McKowen and Bosstick farms two replications on each soil type were used. On the Neyhouse Farm only one replication was used. Electrical conduit pipes were buried 1.4 m (4.5 ft) in the soil and 15 cm (6 inches) of the pipe was allowed to protrude above the soil surface. These neutron probe access pipes were installed in the corn row. Counts were made for 3 minutes for the standard and for each of the 4 depths (30, 61, 91, and 122 cm or 12, 24, 36, and 48 inches) at which soil moisture readings were taken. Soil moisture is reported as percent by volume.

TABLE 2. *Corn grain yields from high yielding soils, 1967-1970.*

Soil type	Farmer	Yield of Corn Grain with 15.5% Moisture				
		1967	1968	1969	1970	Avg.
		High Ground Soils (kg/ha)				
Crosby silt loam	McKowen	5,971	9,157	9,094	7,200	7,856*
Crosby silt loam	Franklin	7,376	8,818	10,612	8,906	8,928**
Reesville silt loam	Priebe	7,288	7,752	9,007	9,621	8,417***
Iva silt loam	Bosstick	11,766	8,542	10,462	10,085	10,214
Reesville silt loam	Neyhouse	10,424	10,060	10,687	9,609	10,195
Average		8,565	8,866	9,972	9,084	9,122
		Low Ground Soils (kg/ha)				
Brookston silt loam	McKowen	9,584	9,584	10,662	10,223	10,013*
Ragsdale silty clay loam	Franklin	9,458	10,060	10,963	8,931	9,853**
Ragsdale silty clay loam	Priebe	9,571	7,476	9,885	10,412	9,336***
Ragsdale silt loam	Bosstick	10,286	9,195	10,575	10,650	10,176
Zipp silt loam	Neyhouse	11,917	9,157	11,302	9,797	10,543
Average		10,163	9,094	10,677	10,003	9,984

* These two average yields are significantly different at the 1% level.

** These two average yields are significantly different at the 1% level.

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Both crop production and soil moisture data were subjected to analysis of variance and F tests of significance. Percentage data were converted to the arc sine and compared.

Results and Discussion

Corn grain yields for the 4-year period varied from a high of 11,917 kg/ha (190.0 bu/A) to a low of 5,971 kg/ha (95.2 bu/A) as shown in Table 2. Both of these yields were obtained in 1967, a very cool year with average air temperatures varying from 1.7 to 4.4°C (3 to 8° F) below normal in August.

Four-year average corn grain yields were significantly higher (1% level) on the low ground than on the high ground soils on three of the five farms (Table 2). The four-year average yield of 9,984 kg/ha (159.2 bu/A) of the low ground soils on all five farms was significantly higher (1% level) than the 9,122 kg/ha (145.4 bu/A) yield of the adjacent high ground soils.

Higher grain yields of corn on the low ground soils were associated with a slightly earlier tasseling and silking. Seven counts made over a three-year period indicated that corn on low ground soils was 58% in silk while that on adjacent high ground soils was 33% in silk. The difference is estimated to be two days earlier in maturity on the low ground soils.

Further evidence that corn tends to grow and mature faster on low ground soils is found in the moisture content of the corn grain at harvest. Corn from the low ground soils of three of the five farms was significantly (1% level) lower in moisture than that from adjacent high ground soils when all four years of data were analyzed. When data from all five farms were combined, corn moisture percentages were significantly (1% level) lower from the low ground than from the high ground soils. The moisture in the corn grain from the high ground soils averaged 26.1%, while that from the low ground soils averaged 24.6%.

To get more information on rate of growth, extended leaf height measurements were made on the Priebe Farm on July 16, 1970. Average height of corn on the Ragsdale silty clay loam or low ground soil was 222 cm (87.4 inches) while that on the Reesville silt loam or high ground soil was 206 cm (81.1 inches).

Higher grain yields of the low ground soils were also associated with higher plant populations. The Franklin Farm location had a significantly higher population of plants on low ground than on high ground soils for the four-year period. When population data of all locations and all years were combined, those data from the low ground soils averaged 57,132 plants/ha (23,121 plants/A), while those from the high ground soils averaged 55,874 plants/ha (22,612 plants/A). The difference in population was significant at the 5% level.

Higher grain yields, faster growth, and higher populations of corn plants were found on the low ground soils. These soils were

TABLE 3. *Selected chemical properties of the plow layer of high yielding soils sampled in 1967.*

Soil type	Farmer	Water pH	Organic matter	Avail-able P	Extractable Bases			Extract-able acidity	Cation Exchange Capacity	Base satu-ration
					Ca	Mg	K			
			(%)	(ka/ha)	(— Milliequivalents/100 g —)					(%)
					High Ground Soils					
Crosby silt loam	McKowen	6.9	2.0	41	7.8	2.9	0.4	4.3	15.5	72
Crosby silt loam	Franklin	7.0	1.2	39	10.1	2.1	0.6	5.1	18.0	72
Reesville silt loam	Priebe	6.6	1.4	17	8.6	2.5	0.6	8.5	20.3	61
Iva silt loam	Bosstick	6.6	1.0	40	8.6	2.2	0.4	5.8	17.1	66
Reesville silt loam	Neyhouse	6.3	0.7	195	4.0	0.4	0.7	5.2	10.3	50
Avg.		6.7	1.3	66	7.8	2.0	0.5	5.8	16.2	64
					Low Ground Soils					
Brookston silt loam	McKowen	6.8	2.6	44	11.9	5.0	0.6	5.2	22.8	77
Ragsdale silty clay loam	Franklin	6.9	2.7	49	19.5	4.0	0.7	4.4	28.7	85
Ragsdale silty clay loam	Priebe	6.3	3.1	151	15.1	4.2	1.0	10.9	31.3	65
Ragsdale silt loam	Bosstick	6.7	2.3	96	13.8	2.8	0.5	6.8	24.0	72
Zipp silt loam	Neyhouse	6.1	1.4	103	9.1	1.7	0.5	7.2	18.6	61
Avg.		6.6	2.4	89	13.9	3.5	0.7	6.9	25.0	72

higher in organic matter, extractable calcium and magnesium, and cation exchange capacity than were the high ground soils (Table 3). It is known that these soil characteristics are interrelated and that they influence soil structure and tilth and hence, crop growth. Under field conditions it is very difficult to prove that one soil characteristic or property results in faster growth or a higher stand. However, it is believed that the higher percentages of organic matter in the low ground soils are very important, particularly in reducing surface crusting and in improving stands. Mannering and Wiersma (6), investigating reduction of infiltration rates in seven different soil types, found that soil texture was important in determining which soils were affected most severely by surface sealing.

Summarized results of soil moisture percentages by volume obtained with a neutron probe in 1970 are given in Table 4. At two locations, the McKowen Farm and the Franklin Farm, total soil moisture (average of four depths) percentages were significantly (1% level) higher on the low ground than on the high ground soils. On the other three farms the same trend was evident, but the differences were not significant.

Soil moisture is often in short supply for corn in July and August in the Corn Belt. Precipitation was very light on the McKowen Farm in both July and August, 1967. The difference of 3,613 kg/ha (57.6 bu/A) between the high ground and low ground soils in their 1967 grain yields on this farm was large. Total inches of available water for corn may have been greater on the Brookston silt loam or low ground soil, partially because it received any run-off of water from the adjacent, higher Crosby silt loam. Lower organic matter on the high ground soil may have contributed to more crusting and run-off. Similarly, low precipitation in July and August probably favored higher yields on the low ground soil, Ragsdale silty clay loam, on the Franklin Farm in both 1967 and in 1968. In 1970, Southern Corn Leaf Blight *(Helminthosporium maydis)*, appeared to have done more damage to corn on the low ground soils and thus reduced some of the advantages of low ground soils with respect to moisture. Low ground soils are, however, sometimes at a disadvantage compared to high ground soils when ponding of water occurs and corn plant populations are reduced.

Even though total soil moisture and that soil moisture available to crops are different on a given soil, sometimes total soil moisture appears to be a good relative measure of soil moisture available to the plant. In 1970, on the Franklin Farm, wilting of corn leaves occurred sooner on the high ground soil which was consistently lower in total soil moisture than the adjacent low ground soil. Also in 1970, free water was found at the bottom of neutron access pipes at a depth of 1.5 m (5 ft) in two of the low ground soils, while no free water was found at this depth in the adjacent high ground soils.

TABLE 4. *Soil moisture content of high yielding soils, 1970.*

Farmer	Times sampled	Soil type	Per Cent moisture content by volume	Soil type	Per Cent moisture content by volume	Is difference between the two soils significant?
		High Ground Soils		Low Ground Soils		
McKowen	2	Crosby silt loam	27.0	Brookston silt loam	33.5	Yes, at 1% level
Franklin	7	Crosby silt loam	22.6	Ragsdale silty clay loam	31.7	Yes, at 1% level
Priebe	7	Reesville silt loam	27.2	Ragsdale silty clay loam	28.6	No
Bosstick	2	Iva silt loam	25.4	Ragsdale silt loam	26.5	No
Neyhouse	2	Reesville silt loam	28.0	Zipp silt loam	31.9	No
		Avg.	26.0		30.4	

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