10-1986

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Uzochukwu, G. A. and Lewis, D. T., "Chemical, Physical and Mineralogical Properties of Mitchell and Tripp Soils in the Nebraska Panhandle" (1986). *Historical Research Bulletins of the Nebraska Agricultural Experiment Station (1913-1993)*. 14.
http://digitalcommons.unl.edu/ardhistrb/14

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Research Bulletin
307

October 1986

by
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TEACHING RESEARCH EXTENSION
IANR

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Issued October 1986, 600

SUMMARY

Mitchell and Tripp soils are some of the most important agricultural soils in the Nebraska Panhandle. Yet, they have received little attention in terms of their basic chemical, physical, and mineral properties. Management decisions can be made on a more informed basis if this kind of information is available. This study was to acquire the information, with special emphasis on mineralogical properties of the soils and their parent materials. This emphasis was given because it is known that other soils in the region contain volcanic ash in measurable amounts. The presence of volcanic ash in soils has been associated with water and nutrient holding capacities greater than those predicted from the soil texture, and with reduced phosphorus availability in soils.

Three pedons of each Mitchell and Tripp soil were selected for detailed study. Mitchell soils formed in colluvial deposits from the Brule siltstone, on broad coalescing alluvial fans originating at the base of escarpments, and sloping gently toward the Platte River. Mitchell pedon sites were located perpendicular to the escarpment known as Scotts Bluff National Monument. Sites were about 2 km (1 mile) apart. Tripp soils formed in old alluvium from the Platte River. They exist on multiple terrace levels at elevations lower than that of the loess-capped terraces of the region. Tripp sites were about 1 mile (2 km) apart on the second terrace level above the present floodplains.

The soils were found to be similar in many respects, but differed in others. Lime was present at very shallow depths in the Mitchell pedons, but existed only below about 60 cm in the Tripp pedons. Both soils had structure in their subsoils, and enough organic matter in their upper soils to be classified as Mollisols. Both soils were found to contain volcanic ash, but the amount present in the Mitchell soil was much greater than that in the Tripp soil. The ratio of percent water held at 15 bars to percent clay equalled or exceeded 0.6 in the control sections of both soils, suggesting that standard techniques did not provide an accurate estimate of total particle surface area. Measured surface area to clay ratios increased with depth, parallel with an increase in ash content, indicating that ash, or a weathering product of ash, may be related to the increased surface area. Very high CEC/clay ratios and X-ray diffractograms suggest that allophane may be present in these soils, but the amount and effect of this allophane on soil fertility relationships requires further study.

It appears that Tripp soils on the older terrace may be somewhat more weathered than the Mitchell soils, but the evidence is not clear, nor is the difference great. Both exist on land surfaces that post-date loess deposition, and pre-date the recent flood plains of the Platte River and other streams of the area. It is suggested that both are Mollisols with cambic subsurface hori-

zons. Hence, the category Aridic Haplustolls appears to suggest their major properties and genesis best. They would be separated at the family level based on their differences in particle size and lime content.

Chemical, Physical and Mineralogical Properties of Mitchell and Tripp Soils in the Nebraska Panhandle

G. A. Uzochukwu and D. T. Lewis[1/]

INTRODUCTION

Mitchell and Tripp soils are some of the most intensively farmed soils in the North Platte River Valley in the Nebraska Panhandle. The majority of both soils are in Scotts Bluff County. The Soil Survey Report of this county (25) lists 113,879 acres of Mitchell and 35,280 acres of Tripp soils. Together, these soils comprise nearly one-third of Scotts Bluff County. Morrill County to the southeast has 29,750 acres of Mitchell, and 24,880 acres of Tripp soil (9). Nearly all of this land is used in production of irrigated corn, sugarbeets, field beans, and alfalfa. The plots at the University of Nebraska Panhandle Research and Extension Center are on Tripp soils.

Despite their large extent and intensive use, little work has been done to establish details of their chemical, physical, and mineralogical properties. It had been suggested (24) that these soils may contain appreciable amounts of volcanic ash. Existing hypotheses (23) suggest that the varying amounts of ash in these soils affect the degree to which they respond to phosphate fertilizer. The purpose of this study was to develop an information base about the properties of these two soils, their genesis and classification, with specific attention given to their mineralogy to determine whether or not volcanic ash existed in large enough amounts to affect their response to irrigated agriculture.

Mitchell soils are classified as coarse silty, mixed (calcareous) mesic Ustic Torriorthents, suggesting that they are basically silty soils of mixed mineralogy that are dry, calcareous, and weakly developed. Tripp soils are classified as coarse silty, mixed, mesic Aridic Haplustolls, suggesting that in some of their properties, they are much the same as the Mitchell soils, except they are not so calcareous in the upper part of their profile (18,20).

Mitchell soils are south of the North Platte River, mostly in the Gering Valley, Mitchell Bottom, and Lyman Plain of Scotts Bluff County. They formed in material weathered from the Brule siltstone. This weathered material was transported and deposited to form short footslopes or broad, nearly level, fan-shaped basin fills (25). Tripp soils are north of the river. They formed in old alluvium from the North Platte River and exist on several terrace levels at elevations greater than those of the present river valley, but at elevations lower than the area's uplands. The highest terraces in the area are capped with loess that is probably of Bignell Age (16). These terraces have loessial soils formed in them.

The climate of the area in which exist the Mitchell and Tripp soils is continental, temperate, and semi-arid. Average precipitation is about 15 inches (375 mm), most of which occurs between April and September. Average maximum and minimum temperatures are 65 and 34 degrees Fahrenheit, respectively.

There exist in the vicinity of Mitchell and Tripp soils many outcrops of rocks of Tertiary Age. Most of these are of the Oligocene Brule siltstone and the Miocene Arikaree sandstone. Beds of volcanic ash are common in these rock formations, and both Brule and Arikaree rocks consist of as much as 50% volcanic glass shards (15).

BACKGROUND ON MITCHELL AND TRIPP SOILS

In many ways, Mitchell and Tripp soils are similar. Both were originally identified in the Nebraska Panhandle (20). Both are deep, well drained, and silt loam, or very fine sandy loam in texture of topsoil and subsoil. Both are considered to have a medium or moderate water holding capacity (25). Their profile morphology as described makes them seem quite different. Yet field observation of the two soils leads one to believe they are much the same. Mitchell soils are considered to have no B horizon and lack a Mollic epipedon. Tripp soils, on the other hand, are considered to have both a B horizon and a Mollic epipedon. Evidence for the B horizon in Tripp soils is in the form of a weakly formed soil structure in the subsoil, and the suggestion that lime has been moved downward from the subsoil and deposited below it in the lower subsoil (BCk horizon). These soils therefore have a cambic subsurface horizon (18). Subsoils of Mitchell soils also have a weak soil structure, but lime is throughout the pedon, with little or no evidence of translocation downward.

Mitchell soils lack a Mollic epipedon, hence are not Mollisols. Moist colors of the Mitchell epipedon are 10YR4/2, suggesting they are too light colored to meet existing criteria for a Mollic epipedon. Moist color of the Tripp epipedon is 10YR3/2 as a rule. This color barely meets the color criteria for a Mollic epipedon. Hence, Tripp soils are considered to be Mollisols, since organic matter content, thickness, base saturation, and structural criteria have been met by the properties of the Tripp epipedon (18).

The location of these soils on the landscape, and the related parent material differences are major differentiating points between soils within these two series. As previously stated Mitchell soils exist on broad, fan-like landforms south of the Platte River. Materials making up these landforms were derived from erosion of the Oligocene Brule siltstone that forms the lower part of major escarpments such as Scotts Bluff Monument and the Wildcat Hills. The surface of these landforms on which Mitchell soils exist is very close in elevation to the floodplain of the North Platte River. Tripp soils exist north of the river on terraces higher in elevation than the present floodplain of the river. These terraces are slightly higher in elevation than the landforms on which many of the areas of Mitchell soils exist. Parent materials on these terraces is old alluvium from the North Platte River. This alluvium was derived from erosion of Tertiary Age rocks, including the Brule siltstone and the sandier Miocene deposits that outcrop along the river valley.

The fact that these terraces are slightly higher in elevation than the colluvial fans south of the river suggests that their surfaces are somewhat older than the surfaces of the fans. Hence, soils on them are older. This logic has been used to explain why Tripp soils have a Mollic epipedon and a developed subsoil (B horizon) while Mitchell soils lack both (25). While the terraces may be somewhat older than the colluvial materials south of the North Platte River, they appear to postdate major loess deposition in the region. The High Plains of the region, the higher terraces, and many other areas of the uplands there are capped with loess of Peoria or Bignell Age (9, 11, 13, 25). This loess is of late Pleistocene (late Wisconsinan) Age. Bignell is the more recent of these two loess bodies. It lies above a Paleosol called the Brady soil that is about 10,000 years old (16). The terraces on which the Tripp soil exist are not capped with loess, suggesting that they postdate the Bignell loess. Therefore, both the terrace surfaces (and the Tripp soils) as well as the colluvial fans south of the river (Mitchell soils) are very recent in terms of geologic time.

MATERIALS AND METHODS

Field Procedure

Sites were chosen in Scotts Bluff County for this study since the largest areas of Mitchell and Tripp soils are there. After study of county soil maps, and after preliminary examination of areas mapped as Mitchell and Tripp soils, two areas were selected for study. Area 1 was within the major area of

Mitchell soils and included the pedon determined by the soil survey to be modal for the Mitchell Series. Area 2 was within the major area of Tripp soils and included the modal Tripp pedon.

Within each of the two areas, three pedons (two in addition to the modal pedons) were selected based on similarity of observable properties. Once sites were selected, pits were hand dug to expose the soil profile. Morphology was described (19) and samples of each horizon were taken for laboratory analysis (20). Peds for determination of bulk density (clod method) were saran coated and allowed to dry in the field.

Laboratory Procedure

Particle size distribution was determined through use of the pipette method after removal of organic matter and carbonates. Sands were separated from silt and clay, and into various fractions by sieving (21). Bulk density was determined at moist condition from saran-coated clods. Total surface area was determined through use of ethylen glycol monoethyl ether (EGME) on a 3-gram air dried sample (4). Water retention at 15 bars tension was determined through use of a pressure membrane apparatus.

Cation Exchange Capacity was determined by extracting the soil with barium chloride-triethanolamine. This procedure is thought to be more effective on calcareous soils like Mitchell and Tripp. In this procedure the soil is leached with $BaCl_2$ solution. The barium replaces the cations held in the soil. These cations pass into a collected leachate. Ammonium acetate is then passed through the soil. The ammonium ion replaces the barium which is collected in a leachate. The amount of barium is determined by atomic absorption analysis. The cations collected in the initial leachate were also measured by atomic absorption (21).

Soil reaction (pH) was measured in a 1:1 soil/water suspension. Organic carbon content was measured by digestion with potassium dichromate (3). Total nitrogen content was determined by use of Kjeldahl digestion (3). Total phosphorus content was determined by digestion with perchloric acid (21).

Mineralogy of the fine clay, coarse clay, and fine silt fractions was determined through use of an X-ray diffractometer. Samples were prepared for analysis following the procedure of Jackson (10). X-ray diffractograms were obtained from magnesium saturated, air dried samples, from glycerol solivated samples, from potassium saturated air dried samples, and from potassium saturated samples that had been heated to 500 °C.

Mineralogy of the coarse silt and sand fractions was determined through study under a polarizing microscope. Carbonates were removed from these samples and coatings of iron oxide were removed from mineral grains through dithionite reduction. Heavy minerals (>2.85 g/cc) were separated from light (<2.85 g/cc) minerals by differential settling in bromoform. Magnetite was removed with a magnet and weighed. Mineral grains were mounted in gelatin (6) on glass slides and minerals were identified and counted following a line count procedure. Six hundred grains were counted on each slide. Mineral suites were determined, and from these data ratios of resistant/non-resistant minerals were determined (17).

RESULTS AND DISCUSSION

Two areas were selected for study of Mitchell and Tripp soils in Scotts Bluff County. Area 1 was on colluvial fans south of the North Platte River where soils were within the Mitchell Series. Area 2 was on terraces north of the river where soils were within the Tripp Series. Three sites were selected within each area. Morphology of the six pedons studied is in Table 1.

All horizons of all pedons were of friable consistence. Dry colors (not shown) were two Munsell values higher than reported for moist colors. Lime was present in all horizons of the Mitchell pedons, while it did not appear until a depth of between 53-69 cm in the Tripp pedons. The apparent removal of this lime from the upper horizons is the primary reason why Bw (Cambic) horizons were recognized in these pedons. Pedogenic structure was as well developed in subsoils of the Mitchell pedons as in subsoils of the Tripp, but because lime did not appear to have been moved, B horizons were not recognized in the Mitchell pedons. Colors of epipedons of the Mitchell pedons were too high in value to be considered as mollic (values cannot exceed 3.5) (18). Those of the Tripp pedons met this criteria, hence were recognized as Mollic epipedons. Removal of the lime with HCl in the A horizon of the Mitchell pedons darkened them enough to meet color criteria for the mollic epipedon. All horizons of the Mitchell soils were silt loam in texture, except of the A horizon at site 1. The clay content of this one (Table 2) placed the sample just inside the silty clay loam textural class.

Physical properties of the six pedons studied is presented in Table 2. Mitchell pedons are all quite silty. The sand they contain is, for the most part, very fine sand (.1-.05 mm dia). Except for site 3 where an apparent buried soil horizon (Ab) existed, clay contents were higher in the upper horizon than in those at greater depths. Bulk density values were about what one would expect from cultivated soils of the region. Surface area increased with depth in the Mitchell pedon (Table 2). This was somewhat surprising because clay content is usually the factor that controls surface area. Since clay content decreased, a decrease in surface area is expected unless clay type changed. Clay types were relatively uniform throughout the pedon (Table 5). Since surface area governs to a large extent the cation and water holding capacities, it is an important consideration in understanding soil

Table 1. Morphology of Mitchell and Tripp pedons at each site sampled in areas 1, 2 and 3.

Horizon	Depth (cm)	Color(moist)	Texture[a/]	Structure[b/]	HCl reaction
Mitchell (Area 1, Site 1)					
Ap	0- 20	10YR4/2	sil	wmgr	slight
A	20- 28	10YR4/2	sicl	wfsbk	strong
AC1	28- 38	10YR5/2	sil	mfsbk	strong
AC2	38- 53	10YR5/2	sil	mfsbk	strong
C1	53- 81	10YR6/2	sil	mfpr	v.strong
C2	81-109	10YR6/3	sil	wcpr	v.strong
C3	109-155	10YR6/2	sil	wcpr	v.strong
C4	155 +	10YR6/4	sil	massive	v.strong
Mitchell (Area 1, Site 2)					
AP	0- 20	10YR4/2	sil	wfsbk	slight
AC1	20- 51	10YR5/4	sil	wmpr	moderate
AC2	51- 81	10YR5/4	sil	wcpr	moderate
C1	81- 97	10YR5/6	sil	massive	strong
C2	97-127	10YR5/6	sil	massive	strong
C3	127-155	10YR5/6	sil	massive	v.strong
Mitchell (Area 1, Site 3)					
AP	0- 23	10YR4/3	sil	wmsbk	slight
AC1	23- 38	10YR4/4	sil	wfsbk	slight
AC2	38- 58	10YR5/4	sil	wmsbk	moderate
AC3	58- 76	10YR5/6	sil	wmsbk	strong
Ab	76- 91	10YR4/3	sil	wcpr	strpmg
ACb	91-130	10YR5/6	sil	wcpr	strong
C	130-155	10YR6/4	sil	massive	v.strong
Tripp (Area 2, Site 1)					
AP	0- 15	10YR3/2	vfsl	wfgr	-------
A	15- 28	10YR3/2	vfsl	wfsbk	-------
Bw1	28- 53	10YR4/2	vfsl	mfsbk	-------
Bw2	53- 84	10YR4/3	vfsl	wfbk	slight
BCk	84-122	10YR5/3	l	wmbk	strong
Ck1	122-132	10YR6/3	l	wcpr	strong
Ck2	132-156	10YR6/3	vfsl	massive	strong
Tripp (Area 2, Site 2)					
AP	0- 13	10YR3/2	vfsl	sfgr	-------
A	13- 31	10YR3/3	vfsl	wfsbk	-------
Bw1	31- 69	10YR4/3	vfsl	wfsbk	-------
Bw2	69- 88	10YR6/2	l	wmpr	strong
BCk	88-119	10YR7/3	l	wcpr	v.strong
Ck	119-155	10YR7/3	vfsl	massive	v.strong
Tripp (Area 2, Site 3)					
AP	0- 20	10YR3/3	vfsl	wfgr	-------
A	20- 46	10YR3/3	vfsl	wfsbk	-------
Bw1	46- 66	10YR4/3	vfsl	wfsbk	-------
Bw2	66- 81	10YR4/3	vfsl	wfsbk	-------
BCk	81-107	10YR6/2	l	mmpr	strong
Ck	107-155	10YR6/3	vfsl	massive	strong

[a/] sil = silt loam
sicl = silty clay loam
l = loam
vfsl = very fine sandy loam

[b/] w = weak
m = medium or moderate
f = fine
c = coarse
gr = granular
sbk = subangular blocky
bk = blocky
pr = prismatic

Table 2. Particle size distribution, bulk density and total soil surface area.

Horizon	Sand %						Silt %	Clay %	Bulk Density[a] g/cc	Surface Area[b] m^2/g
	vfs	fs	ms	cs	vcs	Total				
						Mitchell (Area 1, Site 2)				
AP	20	4	2	—	—	26	51	23	1.4	116.6
A	19	2	2	—	—	23	49	27	1.5	127.8
AC1	18	3	1	—	—	22	52	26	1.3	103.2
AC2	18	3	1	—	—	22	62	16	1.1	138.9
C1	18	4	1	—	—	23	60	17	1.1	186.5
C2	18	3	1	—	—	22	61	17		162.6
C3	18	4	1	—	—	23	60	17		185.8
C4	18	4	1	1	—	24	67	9		163.2
						Mitchell (Area 1, Site 2)				
AP	14	4	1	—	—	19	61	20		
AC1	18	4	1	—	—	19	69	12		
AC2	18	2	—	—	—	20	67	13		
C1	20	5	1	—	—	26	61	13		
C2	23	7	2	1	—	33	61	6		
C3	13	8	3	1	—	25	69	6		
						Mitchell (Area 1, Site 3)				
AP	19	3	—	—	—	22	65	13		
AC1	18	2	—	—	—	20	69	11		
AC2	18	2	—	—	—	20	69	11		
AC3	20	2	—	—	—	22	64	14		
Ab	14	2	1	—	—	17	60	23		
ACb	12	2	1	—	—	15	71	14		
C	14	2	—	—	—	16	70	14		
						Tripp (Area 2, Site 1)				
AP	39	10	2	1	—	52	31	17	1.40	46.1
A	41	12	2	1	—	56	31	13	1.44	50.9
Bw1	40	15	3	1	—	60	24	16	1.31	42.3
Bw2	40	13	2	1	—	57	25	18	1.26	48.5
BCk	36	8	2	1	—	47	45	8	1.17	49.9
Ck1	33	11	2	1	—	47	45	8	1.27	50.4
Ck2	41	10	1	—	—	52	39	9		61.7
						Tripp (Area 2, Site 2)				
AP	43	17	5	2	1	68	17	15		
A	37	11	4	3	1	56	29	15		
Bw1	37	12	4	2	1	56	26	18		
Bw2	35	10	1	1	1	48	39	13		
Bck	36	6	1	—	—	43	47	10		
ck	43	13	1	1	1	59	35	6		
						Tripp (Area 2, Site 3)				
AP	40	15	4	2	—	61	23	16		
A	37	15	4	2	1	59	32	9		
Bw1	37	15	5	2	1	60	24	16		
Bw2	35	17	5	3	1	61	27	12		
Bck	33	7	2	1	1	44	50	6		
Ck	38	9	1	—	—	48	46	6		

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[a] The Mitchell pedon (Area 1, Site 1) and Tripp pedon (Area 2, Site 1) were determined to be modal.

[b] Surface area and bulk density were determined for these pedons only.

response.

Tripp pedons were somewhat more sandy and generally lower in clay than were Mitchell pedons. However, the sand they contained was largely very fine sand (0.1-0.5 mm dia), so in field observation, they do not appear especially sandy. Their clay content also decreased with depth, in general, while their surface area remained the same or increased slightly. Again, clay types were relatively uniform (Table 5) so a decrease in surface area is expected as clay content decreased.

The procedures indicated for soil classification (18) suggest that in soils that appear to be hard to disperse, it is necessary to multiply a factor of 2.5 times the percent water held at 15 bars to determine the clay content. The procedure further suggests that in any case when the ratio of percent water held at 15 bars tension to clay percent as measured by analysis equals or exceeds the factor of 0.6, clay content should be determined by the indicated calculation. This calculation is required for both Mitchell and Tripp pedons (Table 3), suggesting that some factor other than the clay content is controlling the water content at the wilting point (15 bars tension). Surface area to clay ratios increase considerably with depth in both Mitchell and Tripp pedons suggesting that the increased water holding capacity at 15 bars tension is associated with the increasing surface area as one would expect. Calculated clay content suggests that, using the requirement for clay

Table 3. Clay content (from analysis), water content (%) at 15 bars tension, calculated clay content (2.5 x % water at 15 bars), surface area/% clay ratios and % water at 15 bars/clay ratio.

Horizon	Clay %	15 bar water %	15 bar water/clay ratio	Surface area/clay ratio	Calculated clay %
			Mitchell (Area 1, Site 1)		
AP	23	14.0	.61	5.0	35.0
A	27	9.6	.36	4.7	24.0
AC1	26	14.0	.54	4.0	35.0
AC2	16	13.6	.85	8.7	34.0
C1	17	13.4	.79	11.0	33.5
C2	17	16.1	.95	9.6	40.3
C3	17	15.3	.90	10.9	38.3
C4	9	12.8	1.42	18.1	32.0
			Tripp (Area 2, Site 1)		
AP	17	9.6	.56	2.7	24.0
A	13	9.5	.73	3.9	23.8
Bw1	16	9.6	.60	2.6	24.0
Bw2	18	11.4	.63	2.7	28.5
BCk	8	11.9	1.50	6.2	29.8
Ck1	8	10.0	1.25	6.3	25.0
Ck2	9	9.4	1.04	6.9	23.5

measurement specified by the classification system, both these soils behave as soils with much higher clay contents than standard particle size analysis would indicate.

Chemical properties of pedons sampled show a relatively constant cation exchange capacity throughout the pedons (Table 4). Considering the fact that clay types are similar throughout depth (Table 5) and clay content (Table 2) as well as organic matter content decrease with depth, the lack of a decrease in cation exchange capacity must be associated with an increasing surface area as depth increases. Organic carbon content of Mitchell epipedons are equal to slightly higher than those of Tripp epipedons, yet Tripp epipedons are darker in color. Carbon to nitrogen ratios do not suggest a differential degree of organic matter decomposition between the epipedons. Therefore, the darkness difference must be due to some other factor, the most likely of which is the presence of lime in the Mitchell epipedon. As previously indicated, the Mitchell epipedon was as dark as that of the Tripp once the soil had been reacted with HCl to remove the lime.

Cation exchange capacity to clay ratios (using clay content measured in the lab) are very high. Ratios of 0.7 or higher are usually taken to indicate that montmorillonite clays dominate the clay fraction. Cation exchange capacity/calculated clay (2.5 times % water at 15 bars) ratios were all 0.7 or 0.8. Using either ratio, it suggests that a mineral with a very high cation exchange capacity dominates the clay fraction. X-ray diffractograms suggested that montmorillonite was present, particularly in the fine clay fraction (< 0.2 microns), but it was not the only clay mineral there and from the shape and size of peaks on the diffractogram, montmorillonite was not the most abundant clay type present (Table 5). In addition, montmorillonite did not appear to increase with depth. Its presence, therefore, cannot account for the uniformity of cation exchange capacity with depth and accompanying decrease in clay content and organic matter. The increasing surface area with depth, the increasing percent water held at 15 bars with depth, and the increasing CEC/clay ratios with depth must be associated with a factor other than the changing of clay types with depth.

The answer to this apparent anomalie may lie with the content of volcanic ash in both these soils (Table 7). Ash is especially high in the Mitchell pedon. Volcanic ash has been associated with greater than expected surface area in soils (8, 14), and with cation exchange values higher than would be expected, considering amount and kind of clay (22). In soils of the upland near the study area, ash has been associated with surface areas and potentially greater water holding capacities at the wilting point (15 bars tension) and cation exchange capacity than nearby soils that contain little or no ash (1, 12). It is uncertain whether it is the ash itself or the weathering products of ash that are responsible (7). Weathering products of ash include the com-

Table 4. pH, CEC, extractable cations, organic carbon, total N and total P contents of Mitchell and Tripp pedons studied.

			Extractable cations								
Horizon	pH	CEC	Ca	Mg	K	Na	CEC/clay	O.C	N	C/N[a]	P
		me/100g soil					ratio	%	%	ratio	ppm
Mitchell (Area 1, Site 1)											
AP	7.8	25.6	20.3	5.2	1.6	0.4	1.1	1.3	.13	10	544
A	7.8	25.0	21.0	5.5	1.7	0.5	0.9	1.2	.13	9	605
AC1	7.8	25.8	21.8	5.4	1.6	0.4	1.0	0.9	.10	9	605
AC2	7.9	26.2	24.8	5.4	1.5	0.5	1.6	0.6			670
C1	7.9	24.4	21.4	4.4	1.6	0.5	1.4	0.5			739
C2	7.9	26.4	25.9	5.0	1.4	0.6	1.6	0.4			739
C3	7.0	25.8	24.2	4.5	1.4	0.6	1.5	0.2			741
C4	8.0	26.0	25.7	4.6	1.5	0.6	2.9	0.1			745
Mitchell (Area 1, Site 2)											
AP	7.8	26.6	19.2	5.2	1.8	0.6	1.3	0.9	.11	9	670
AC1	7.9	25.9	21.1	5.1	1.3	0.8	2.2	0.4	.11	9	704
AC2	7.9	25.6	22.5	4.9	6.6	0.7	2.0	0.1			637
C1	8.0	23.4	20.9	4.2	6.2	0.6	1.8	0.1			637
C2	8.0	22.8	18.4	3.6	7.0	0.7	3.8	—			605
C3	8.0	25.0	21.8	4.0	9.2	0.7	4.2	—			514
Mitchell (Area 1, Site 3)											
AP	8.0	25.6	23.0	4.9	2.7	0.6	2.0	1.0	.12	9	739
AC1	7.9	25.4	25.0	4.4	1.1	0.6	2.3	0.5	.12	9	775
AC2	8.0	25.3	25.0	4.6	1.0	0.7	2.3	0.3			775
AC3	8.1	25.5	25.7	5.6	1.4	0.7	1.8	0.3			704
Ab	8.0	27.1	27.2	7.4	2.3	0.7	1.2	0.5			617
ACb	8.0	27.7	26.4	7.2	2.9	0.1	2.0	0.2			775
C	8.1	28.0	26.1	7.4	3.1	1.1	2.0	0.1			670
Tripp (Area 2, Site 1)											
AP	7.6	19.4	16.6	4.3	1.7	0.3	1.1	0.9	.19	9	514
A	7.5	19.1	14.9	4.1	1.8	0.7	1.5	0.8	.08	9	514
Bw1	7.5	19.2	14.1	4.1	1.7	0.4	1.2	0.5	.06	9	431
Bw2	7.9	19.5	20.3	4.2	0.9	0.5	1.1	0.3			605
BCk	8.0	21.4	22.3	4.2	1.0	0.7	2.7	0.2			574
Ck1	8.1	19.0	19.7	4.0	1.3	0.6	2.4	0.2			574
Ck2	8.1	18.6	18.7	4.3	1.3	0.6	2.1	—			574
Tripp (Area 2, Site 2)											
AP	7.4	18.7	15.0	4.1	1.2	0.3	1.3	0.6	0.7	9	354
A	7.5	18.6	14.5	4.0	1.4	0.5	1.2	0.6	0.7	9	354
Bw1	7.7	19.8	16.8	4.1	1.0	0.7	1.1	0.2			379
Bw2	7.9	20.9	21.5	4.8	0.4	0.8	1.6	0.1			486
Bck	8.0	18.9	22.7	4.7	0.5	0.8	1.9	0.1			514
Ck	8.0	18.6	19.6	4.2	0.9	0.6	3.1	—			458
Tripp (Area 2, Site 3)											
AP	7.6	18.6	13.8	3.3	1.6	0.4	1.2	0.7	0.8	9	458
A	7.6	18.7	14.5	3.5	1.2	0.4	2.1	0.6	0.8	8	458
Bw1	7.6	17.5	14.3	3.6	1.1	0.4	1.2	0.4			379
Bw2	7.8	17.7	13.8	3.6	1.2	0.4	1.5	0.3			354
BCk	8.2	18.7	19.9	4.2	0.8	0.5	3.1	0.2			431
Ck	8.2	19.0	19.5	4.8	0.8	0.6	3.2	0.1			486

[a] Nitrogen and C/N ratios were determined in upper horizons only.

Table 5. Major clay types present in fine silt, coarse clay, and fine clay fractions of Modal Mitchell and Tripp pedons[d]

Horizon	Fine silt	Coarse clay	Fine clay
Mitchell (Area 1, Site 1)			
AP	Illite	Illite	Mont./illite
A	Illite	Illite/mont.[a]	Mont./illite
AC1	Illite	Illite	Mont.
AC2	Illite	Illite	Mont./verm.
C1	Illite	Illite	Mont./illite
C2	Illite	Illite/mont.	Illite
C3	Illite	Illite/mont.	Mont./illite
C4	Illite	Illite/mont.	Mont.
Tripp (Area 2, Site 1)			
AP	Illite	Illite/mont.	Mont./verm.
A	Illite	Vermiculite	Verm./mont.[c]
Bw1	Illite	Illite/mont.	Verm./mont.
Bw2	Illite	Illite	Vermiculite
BCk	Illite	Illite/mont.	Vermiculite
Ck1	Illite	Mont./illite[b]	Verm./mont.
Ck2	Illite	Mont./illite	Mont./illite

[a] Indicates both illite and montmorillonite were present, but that illite appears to be most abundant.

[b] Indicates that both montmorillonite and illite were present; montmorillonite most abundant.

[c] Indicates presence of both vermiculite and montmorillonite; vermiculite most abundant.

[d] Both Kaolinite and quartz were common in fine silt and coarse clay fractions. The amount appeared to be very small, however. These minerals were not evident in the fine clay fractions of either pedon.

monly identified clays, as well as amorphous clays like allophane (2). Amorphous clays do not appear clearly on X-ray diffractograms, so it is uncertain whether or not they exist in these soils. However, these clays tend to be very high in cation holding capacity, and one may speculate that in view of the very high CEC/clay ratios of these soils, that weathering products of ash may be involved. This is an area that requires further study.

Another area of uncertainty is the relationship of the ash in these soils to their phosphate fertilizer response, as reported for these soils earlier (24). Volcanic ash has been associated with phosphorus "fixation" (12). Again, it is probably as much the weathering products of the ash as the ash itself that is responsible. Both soils contain considerable amounts of total phosphorus (Table 4). They also contain higher amounts of apatite (phorphorus bearing) minerals (Table 6) than are usually noted in soils of the region (1). In addition, ample lime is present, especially in the Mitchell soils, to render phosphorus unavailable (24). Just what role ash plays in this is not clear at this time.

Neither the Mitchell nor Tripp soils appear highly weathered. Both contain relatively large amounts of olivene, a very easily weathered mineral (5) (Table 7) and ratios of quartz (resistant) to Feldspar (weatherable) minerals

Table 6. **Heavy minerals (>2.85g/cc) in the sand and coarse silt fractions. Values, except for magnetite are expressed as percent of the heavy mineral fraction as determined by count. Magnetite is expressed as a percent (by weight) of the total heavy mineral weight. Total heavy minerals are expressed as a percent (by weight) of the total sand and coarse silt fractions.**

Horizon	Total Heavy minerals	Magnetite	Opaque	Amphibole	Apatite	Olivene	Pyroxene	Epidote	Tourmaline	Unknown[a]
Mitchell (Area 1, Site 1)										
AP	2.8	3.8	14.6	22.9	6.5	3.2	18.3	10.2	1.6	22.7
A	2.9	4.0	15.8	25.7	8.3	2.0	17.1	9.3	1.4	20.4
AC1	3.0	3.1	16.1	25.3	8.6	2.4	14.1	10.4	1.8	21.3
AC2	2.9	3.5	15.9	28.1	9.2	2.1	15.4	8.8	1.9	18.6
C1	2.8	3.7	10.4	28.3	9.4	1.8	17.6	6.5	1.7	24.3
C2	3.0	4.1	13.8	29.2	10.0	2.9	15.2	6.6	1.4	20.9
C3	3.0	3.3	9.6	30.4	8.0	2.3	18.1	8.9	1.5	21.2
Tripp (Area 2, Site 2)										
AP	2.9	3.2	15.2	20.6	4.0	3.0	13.2	9.9	1.5	32.6
A	3.0	3.6	16.3	19.9	3.0	3.2	16.0	8.7	1.7	31.2
Bw1	2.8	3.4	14.4	21.3	3.7	2.1	17.5	9.5	2.4	29.1
Bw2	3.0	4.0	17.2	22.0	4.5	3.6	14.1	8.5	2.5	27.6
BCk	3.0	3.7	13.8	23.2	4.0	1.4	15.3	10.3	2.1	19.9
Ck	2.9	3.8	16.5	24.4	4.6	2.8	16.5	6.7	1.9	32.6

[a] Unknown minerals were those grains that appeared to be weathered so strongly that their optical properties could not be used in identification.

Table 7. Light minerals (< 2.85 g/cc) in sand and coarse silt fractions. Total light minerals are a percent (by weight) of the sand and coarse silt fractions. Specific minerals are a percent of the light minerals as determined by a line count method under the polarizing microscope.

Horizon	Total light minerals	Volcanic glass (ash)	Feldspars	Quartz	Unknown[a]	Quartz/Feldspar ratio
			Mitchell (Area 1, Site 1)			
AP	97.2	38.4	15.1	30.5	16.0	2.0
A	97.1	40.8	16.2	29.1	13.9	1.8
AC1	97.0	42.1	16.0	30.0	11.9	1.9
AC2	97.1	45.6	15.8	32.4	6.2	2.1
C1	97.8	51.8	15.6	28.4	4.2	1.8
C2	97.0	52.2	14.8	28.2	4.8	1.9
C3	97.0	48.1	15.2	30.0	6.7	2.0
			Tripp (Area 2, Site 1)			
AP	97.1	30.5	15.8	46.4	7.7	1.5
A	97.0	32.8	16.0	40.2	11.0	2.5
Bw1	97.1	31.6	14.4	45.9	8.1	3.2
Bw2	97.0	26.0	14.8	48.0	11.2	1.8
BC	97.0	40.2	15.8	37.6	6.4	2.4
Ck	97.1	30.6	18.5	40.7	10.2	2.2

[a] Unknkown minerals were those grains that appeared to be weathered so strongly that their optical properties could not be used in identification.

show only slight and irregular changes with depth. An exception to this is the Bw horizon of the Tripp soil. Here, an increase noted may suggest that greater weathering has occurred in the Tripp subsoil. Olivene content also drops in that horizon. This suggestion of increased weathering in the Tripp soil is reasonable considering the somewhat older land surface of the Tripp soils compared to that of the Mitchell soils. However, Tripp soils formed in alluvium, a deposit that is commonly stratified. These differences may simply be due to original differences in the parent material.

CONCLUSIONS

Soils of the Mitchell and Tripp Series have some strong similarities. Both are of medium texture, both are deep, well-drained and important to the agriculture of the region in which they exist. Both contain volcanic ash as a significant part of their mineral fraction. The effect of this ash on other soil properties such as surface area, water holding content at the wilting point, and cation exchange capacity may be implied from findings from other studies, and from the fact that in these soils as ash content increases, so does surface area and water content at 15 bars tension. Also, since cation exchange capacity does not decrease as clay content decreases, and since clay types remain relatively constant within the clay fraction, it is probable that the increasing ash and/or its weathering products account for a higher CEC per unit clay in these soils than is normally seen for the clay types present. It is also probable, based on findings from other areas, that the ash content has some control over phosphorus relationships in these soils, although the degree and extent of this control cannot be judged from this study.

Both Mitchell and Tripp soils are limy, but the lime is present in Tripp soils only below the A horizon. It is present throughout the Mitchell pedon. pH values are all above 7.5 in all horizons of both soils, and calcium is the major ion on the exchange complex. There appears to be ample calcium present to render phosphorus unavailable, and influence phosphorus response from these soils. Neither soil contains appreciable sodium, therefore, the problems often associated with high sodium content in soils are not likely to occur. This is especially true considering the amount of calcium present. Potassium is high enough to preclude the necessity of adding this element as fertilizer.

Land surface age of the geologic deposits on which these soils exist as well as their mineral suites suggest that neither of these soils is very strongly weathered. Their mineralogy is no doubt controlled completely by the mineralogy of the Tertiary Rock from which their parent materials were derived. Considering the amount of volcanic ash present in the Oligocene and Miocene rocks of the area, it would be unusual indeed if the soils there did not contain some ash. The very high amount, especially in the Mitchell soils, was surprising.

Classification of these soils suggests that there is a much greater difference between these soils than their actual properties support. Tripp soils are Mollisols based only on one Munsell value difference in color. This is most likely due to the presence of lime in the Mitchell epipedon. Organic carbon levels are higher in the epipedons of the Mitchell than in the epipedons of the Tripp soils. One could argue that neither of these soils have B horizons (Cambic) since the only evidence of the B horizon in the Tripp soil is that they contain no lime. Few of the structures such as filamentous lime concentration were evident in the pedon to support the suggestion that lime had leached from the B horizon of Tripp soils. However, these lime concentrations were apparent in some of the Tripp Pedons examined in the field, especially those on terrace level 2 above the Platte Valley. Following the evidence gathered, we suggest that both soils should be considered to be Mollisols, that both have cambic horizons (Bw horizons) and that both should be Aridic Haplustolls. This name would suggest the similarity of major genetic properties they possess. Separation would then be made at the family level, for Mitchell soils are more calcareous than Tripp soils. The name would then suggest the strong similarities that exist between these soils. They differ mainly in their depth to lime, and in their landscape positions and accordant parent materials. These differences are used at Family and Series level of differentiation. We also suggest that somewhere in the family name it would be useful to indicate that volcanic ash is a major component of their mineral fraction.

The unclear association between the ash in these soils, the presence (or lack of it) of weathering products of ash, and the effect these have on response of these soils to management needs further work. This is especially true in terms of phosphorus relationships and available water holding capacity. At this time it is uncertain what (if any) effect the ash has on these factors, even though other workers have reported that relationships indeed exist elsewhere.

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