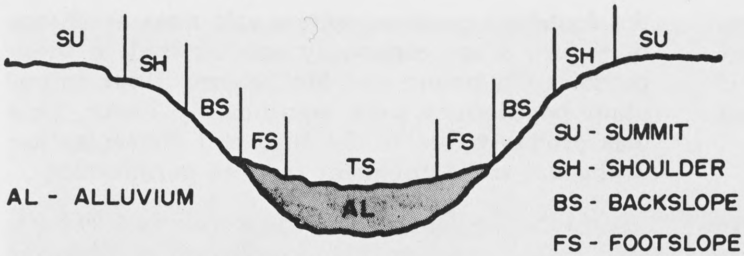

Figure 1. Slope-Profile Components in a Closed System (Ruhe 1969).

Plant Height and Yield of Sunflowers at Different Landscape Positions

D. D. Malo and B. K. Worcester

Sunflower production in North Dakota has increased greatly in the last 10 years. Consequently, soils with widely differing properties have been utilized in their production. Among factors which influence sunflower yields are salinity and plant population (Zubriski, 1971).

Many acres of sunflowers are planted annually outside the Red River Valley on the glacial till plain where large numbers of closed depressions or potholes occur. A closed depression is shaped such that all runoff is contained within the system. Slope-profile components can be defined in closed systems as summit, shoulder, backslope, footslope and toeslope (Figure 1; Walker and Ruhe, 1968). Soil properties follow systematic patterns of distribution on this landscape. Properties such as organic carbon content, bulk density, texture, salinity and pH vary with landscape position in a predictable and repeating manner (Malo, 1974). Knowledge of these relationships on a hillslope can aid in understanding crop growth at various landscape positions.

Methods and Materials

A representative closed drainage system was chosen on the glacial till plain of North Dakota for this study. The system investigated is in the NE¼ SW¼, Sec. 6, T138N, R55W, Cass county, North Dakota. All five slope profile components were present.

A detailed topographic map of the site was constructed with one-foot contour intervals to establish mean sea level elevation at the site, define watershed divides, determine the area of the watershed, and provide a basis for quantitative description of the landscape. A transect was chosen on the hillslope with the longest linear backslope configuration. Soil sample sites and plots for plant observations were established along this transect (Figure 2).

Plant observations were made at nine plot locations in 1972 along the transect (Table 1). At each plot, four 100-square-foot subplots were located. To study the effect of hillslope location on crops, initial plant populations were recorded, plant heights after emergence were measured at various times, general crop appearance was monitored and yields were measured.

The rooting habit of sunflowers was examined. Two sites were located along the transect at the shoulder and mid-backslope positions. Pits were dug adjacent to the sunflower plants and lateral rooting patterns were observed. Soil samples containing roots were taken in three-inch

Table 1. Identification and Location of Plant Observation Plots.

Plot Number	Landscape Position	Distance From the Summit (ft)	Mean Sea Elevation (ft.)
1	Summit	72.0	1188.6
2	Shoulder	114.0	1187.5
3	Upper backslope	158.0	1185.9
4	Backslope	180.0	1185.0
5	Backslope	200.0	1183.8
6	Lower backslope	222.0	1182.9
7	Upper footslope	240.0	1181.8
8	Lower footslope	284.0	1179.3
9	Toeslope	306.0	1178.0

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increments starting at the soil surface. Samples were weighed and washed through a 1 mm sieve. Roots remaining on the sieve were dried at 65°C and weighed. A subsample of the soil was taken to determine initial moisture content by weight.

Results and Discussion

Initial plant populations showed differences with respect to landscape position (Table 2). At the footslope position, where salt rims as shown in Figure 3 are commonly encountered in these potholes (Redmond and McClelland, 1959), initial plant populations were significantly lower. This was probably due to the high salt concentration in the soil and subsequent reduced germination.

Following emergence, the sunflowers reflected height and general appearance differences

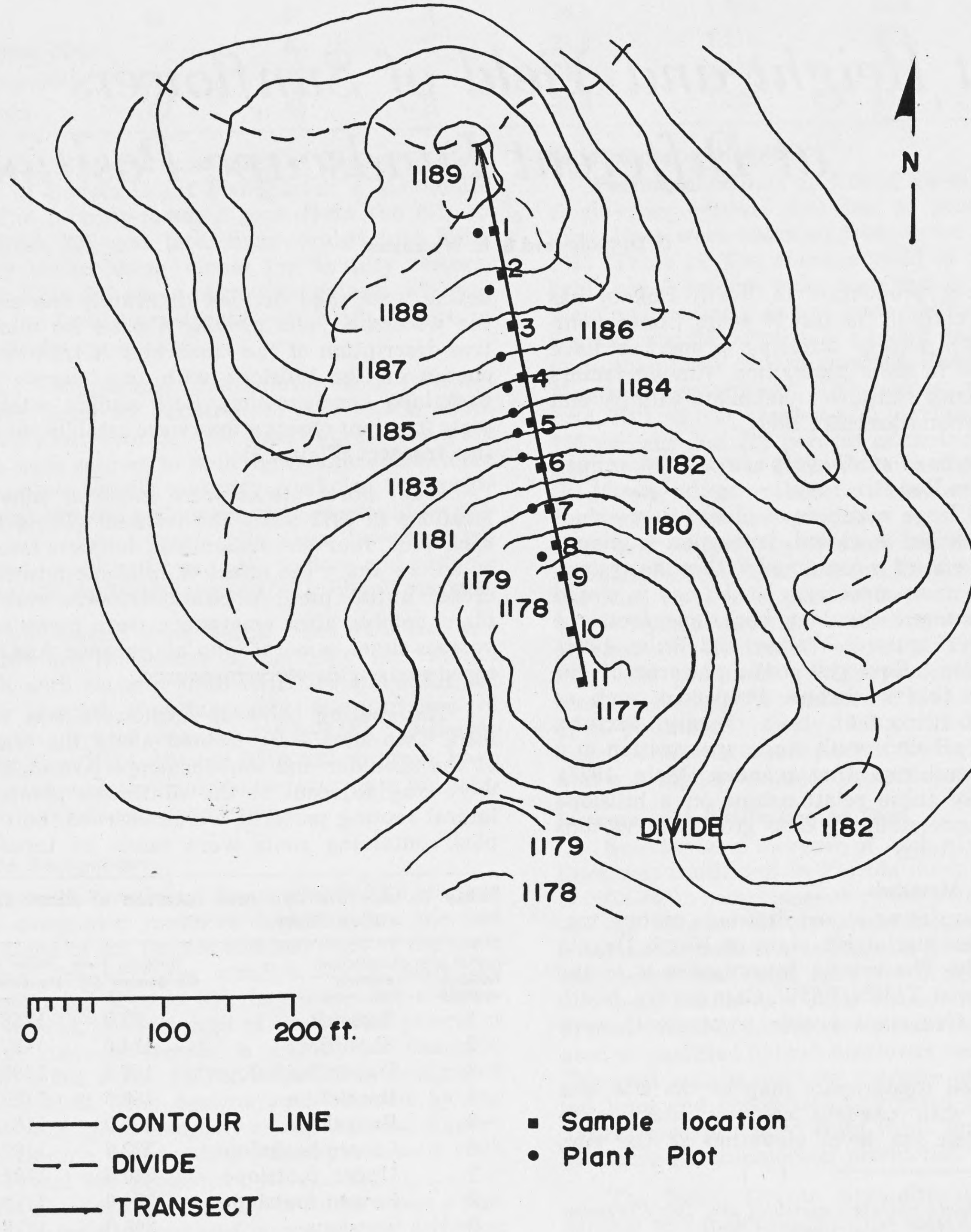

Figure 2. Topographic Map of Study Area.

Figure 3. Prairie Pothole with Salt Rim.

with respect to landscape position even though fertilized at the same rate. The tallest sunflower plants were found at the backslope position (Figure 4). A slight decrease in plant height was noted at the shoulder while a large decrease in plant height was observed at the lower footslope. The decrease in sunflower height at the shoulder position reflects the erosional condition present at this landscape position. Soil development is minimal here, resulting in Buse type soils. The plants here are subject to moisture stress.

The large decrease in plant height at the footslope appears to be associated with the occurrence of a large amount of salts. High salt concentrations cause high osmotic pressures in the soil water, which are detrimental to plant growth. During the first 20 days following emergence, sunflower plants at the toeslope increased in height comparable to other landscape positions. From 20 to 45 days following emergence, the rate of growth at lower landscape positions was less than at the summit, shoulder and backslope locations. The water table was closer to the soil surface at lower landscape positions, and thus may have affected the sunflower plants (Malo **et al.,** 1973). Saturated conditions close to the soil surface tended to inhibit root growth. The decrease in precipitation in late summer, along with increased evapotranspirational losses, caused the water table to lower. Following the drop in water table level, the plants reached a height of more than 60 inches.

Table 2. Initial Sunflower Plant Populations at Different Landscape Positions.

Plot Number	Number of Plants/10' of Row	Number of Plants/Acre
1	13.3	17420
2	14.0	18300
3	13.3	17420
4	14.0	18300
5	12.7	16560
6	11.0	14380
7	10.3	13500
8	6.3	8270
9	8.7	11330

Along with plant height, maturity of sunflower plants can be related to landscape position. Response was similar to that found for plant height. Footslope plants were short and did not bloom as early as at other landscape positions.

Moisture content of the grain at harvest was related to landscape position (Figure 5). Moving from the summit to the toeslope, the grain moisture content increases, while at the same time the depth to the water table decreases (Malo **et al.,** 1973). Consequently, moisture contents of soils at lower landscape positions tended to be higher. This delayed maturity and thus, when the crop was harvested, the seeds from the lower landscape position contained more moisture.

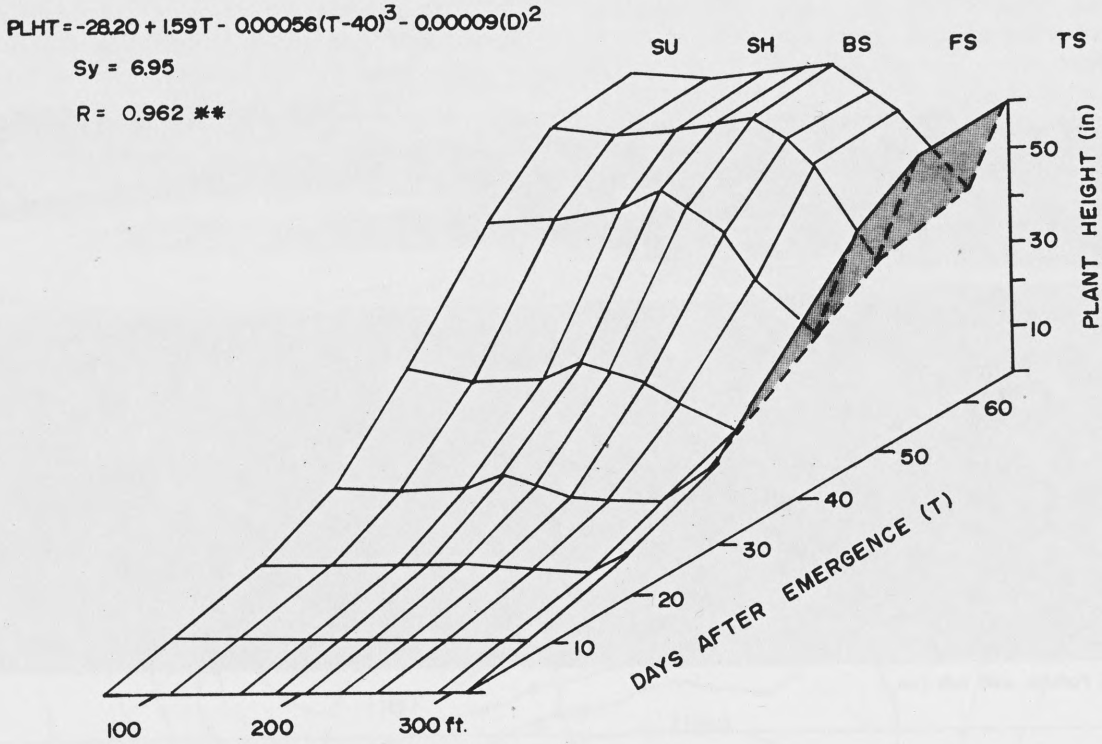

Figure 4. Relationships Between Sunflower Plant Height (PLHT), Landscape Position (D) and Days After Emergence (T) Along the Hillslope Transect. Su = Summit, Sh = Shoulder, Bs = Backslope, Fs = Footslope and Ts = Toeslope.

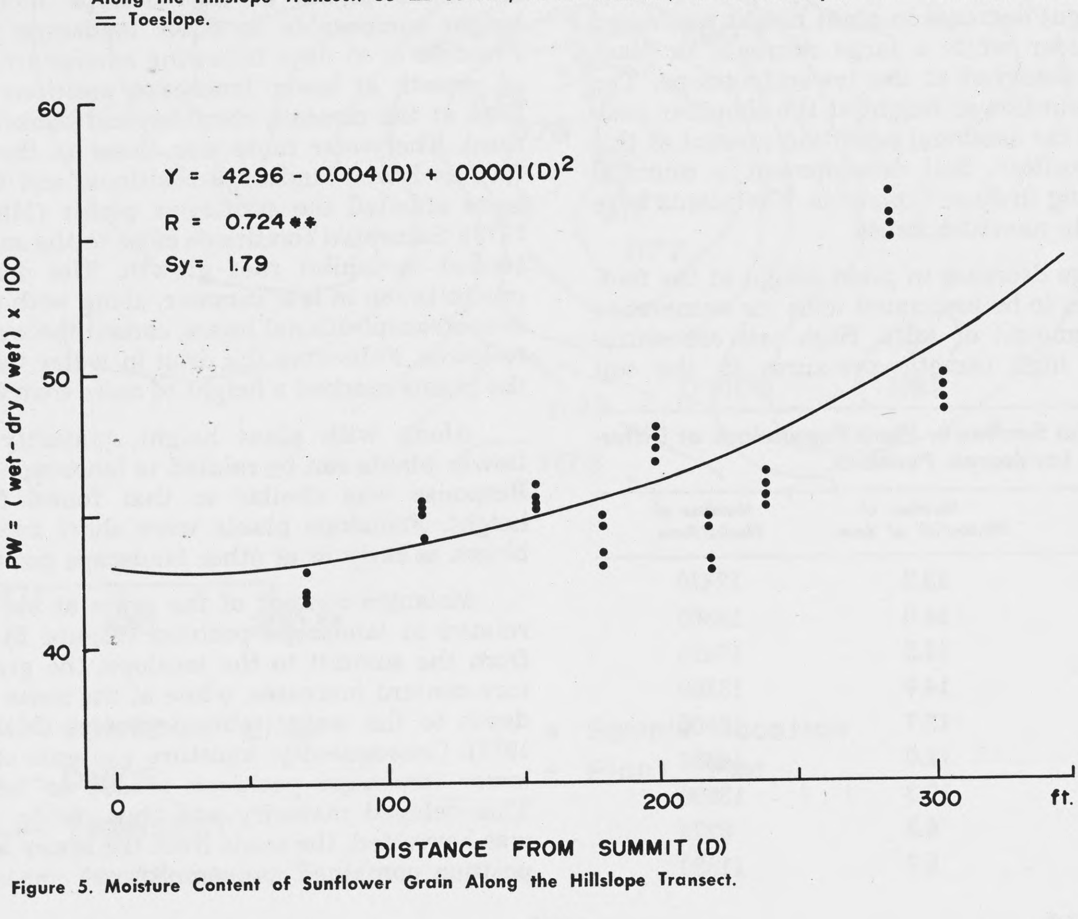

Figure 5. Moisture Content of Sunflower Grain Along the Hillslope Transect.

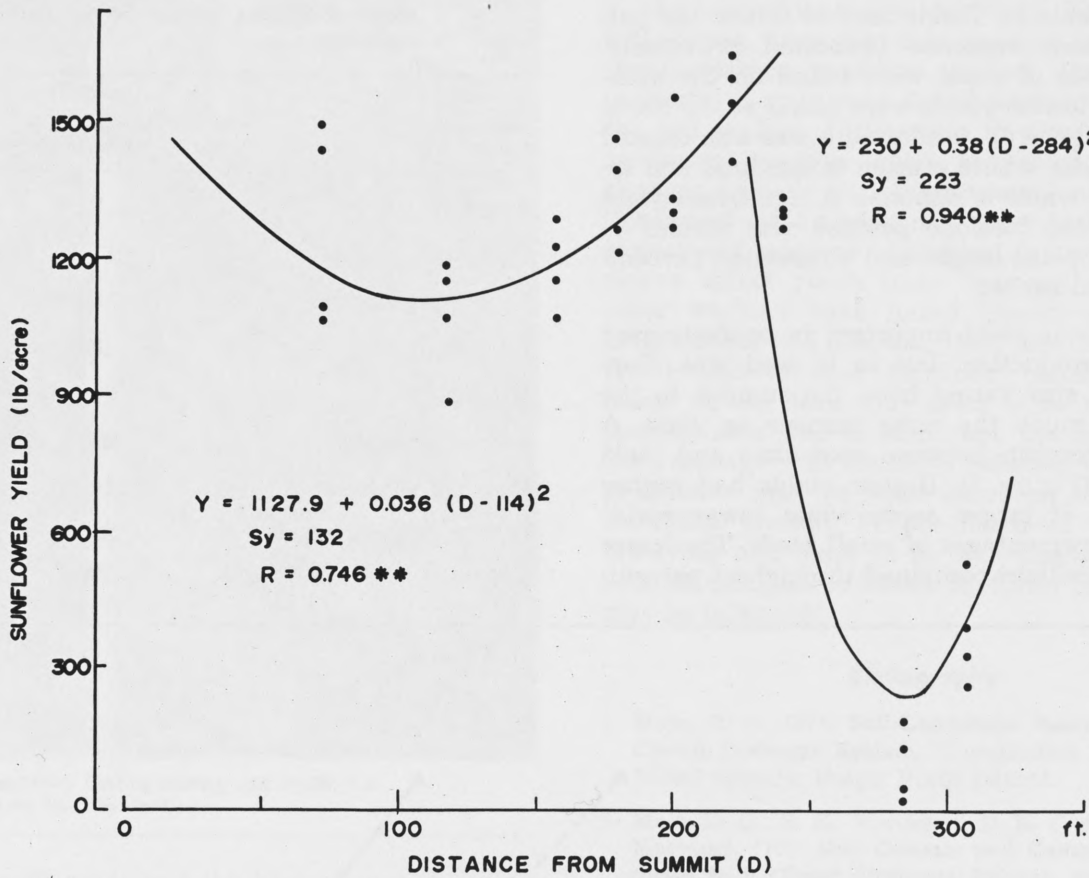

Figure 6. Sunflower Yields Along the Hillslope Transect.

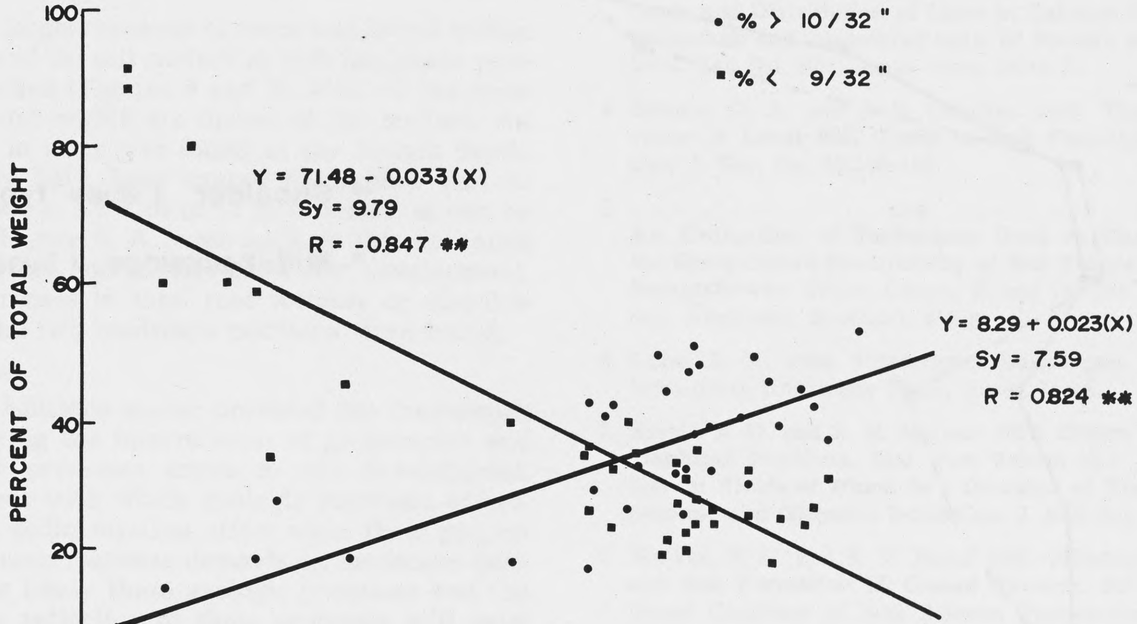

Figure 7. Sunflower Seed Size Versus Sunflower Yield.

Sunflower yields differed at various landscape positions (Table 3). Yields tend to follow the patterns of plant response presented previously. Highest yields of grain were found on the backslope while lowest yields were found at the lower footslope (Figure 6). A minimum was also located at the shoulder where erosion is maximal and infiltration of water is minimal. A significant yield increase at the toeslope position was similar to the data for plant height and blossoming percentage discussed earlier.

Not only is yield important in confectionary sunflower production, but so is seed size. Sunflower seed size varied from the summit to the toeslope in much the same manner as yield. A linear relationship between seed sizes and yield was found (Figure 7). Higher yields had higher percentages of larger seeds while lower yields had higher percentages of small seeds. The lower landscape positions contained the highest percent-

Table 3. Yields of Sunflowers (1972) at Various Landscape Positions under Same Fertility Management.

Landscape Position	Plot Number	Distance From Summit (ft)	Average Yield Lb/Acre
Summit	1	72	1262
Shoulder	2	114	1067
Upper backslope	3	158	1178
Backslope	4	180	1323
Backslope	5	200	1357
Lower backslope	6	222	1545
Upper footslope	7	240	1302
Lower footslope	8	284	102
Toeslope	9	306	376

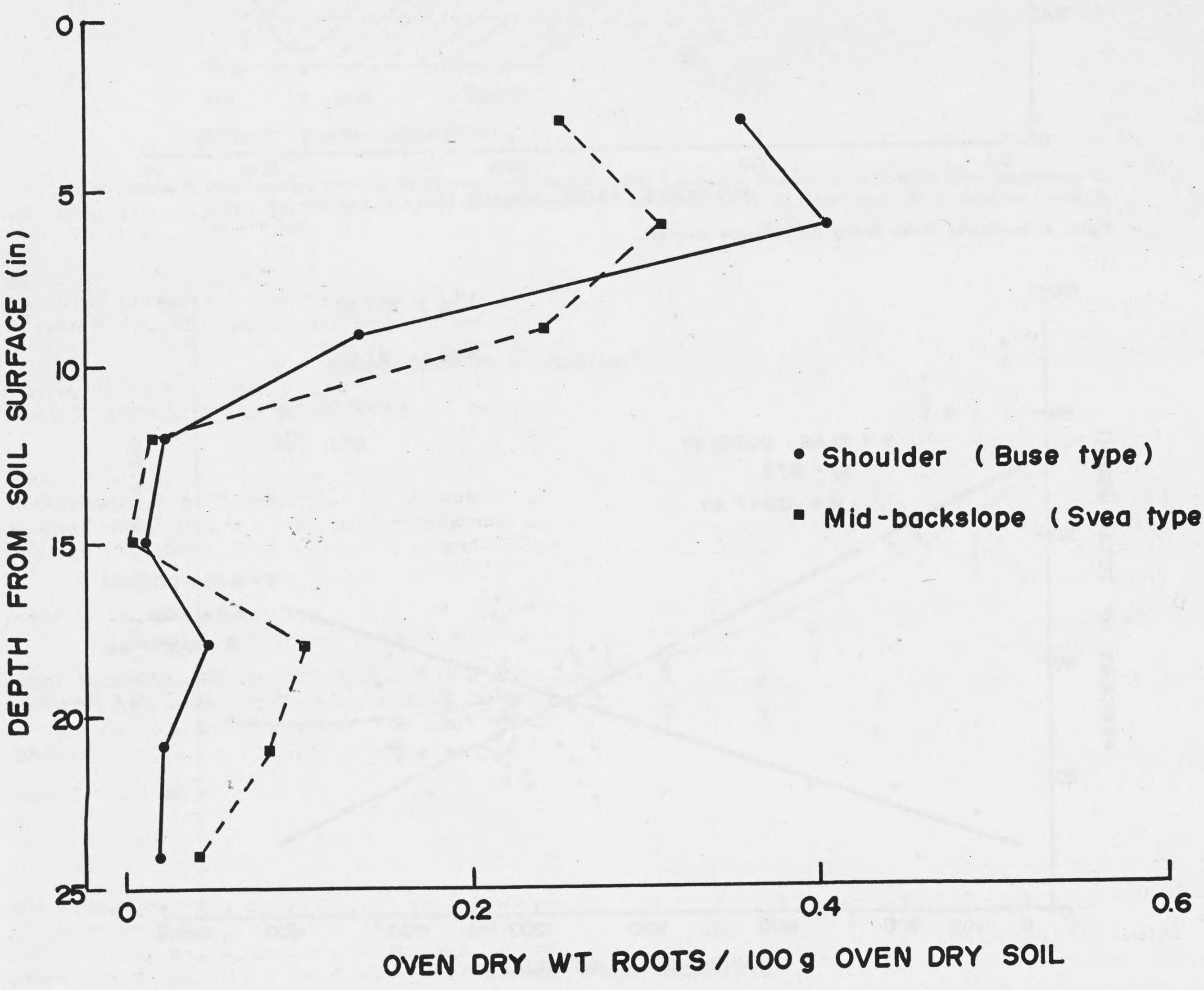

Figure 8. Sunflower Root Distribution at Two Landscape Positions.

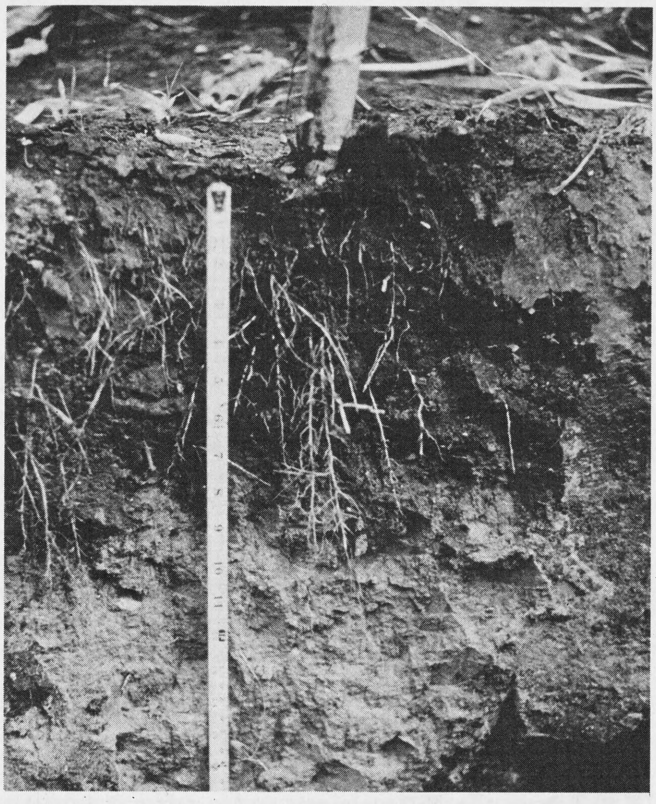

Figure 9. Sunflower Rooting Pattern and Traffic Pan at the Shoulder Position.

age of small seeds and the highest moisture content, while upslope were higher yields of larger seeds at less moisture content.

The largest amount of roots was found within 12 inches of the soil surface at both landscape positions studied (Figures 8 and 9). Most of the roots were found within six inches of the surface. An increase in roots was found at the 18-inch depth. This may have been caused by a plow pan or traffic pan at a depth of 12 to 15 inches as can be seen in Figure 9. A layer such as this can alter soil structure and restrict plant root development. No differences in total root weights or distribution at the two landscape positions were found.

Conclusions

The hillslope model provided the framework for studying the interrelation of geomorphic and pedologic processes active in soil development. The degree with which geologic processes of erosion and sedimentation affect soils, their properties and crop response depends on landscape position. It is likely these geologic processes and the pedologic reflection of these processes will exist on other similar landscapes and under similar conditions present in North Dakota.

Initial plant populations, plant height, maturity, percent moisture at harvest, yield and seed size were related to landscape position. Lowest yields and highest moisture contents were found at the lowest landscape positions. No significant differences were found in rooting habits at the two landscape positions studied. The largest quantity of roots was found within 12 inches of the soil surface. Differences in plant response to landscape position exist primarily because of changes in soils and their associated properties. Continued yield studies may show that basic pedological and microclimatological factors of the soil catena affect yields more than soil fertility, as other workers have found (Spratt and McIver, 1972; Rennie and Clayton, 1960, 1966). Consequently, it follows that fertilizer recommendations based on soil tests may need to be modified for specific soils due to landscape position. In addition, management decisions relevant to sunflower production may be made based on soil-landscape condition present. Where much of the land is low-lying and tends to be wet, management procedures designed to hasten maturity of sunflowers may be initiated.

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