THE JOURNAL OF AGRICULTURE
OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, for the publication of articles by members of its personnel, or others, dealing with any of the more technical aspects of scientific agriculture in Puerto Rico or the Caribbean Area

Vol. LVIII JULY 1974 No. 3

Soil Compaction Due to Harvest Traffic in Sugarcane Fields on a Lajas Valley Farm of Puerto Rico[1]

Lal N. Shukla[2]

INTRODUCTION

Sugarcane in Puerto Rico was cut by hand until only a few years ago. After cutting, it was loaded mechanically into small carts and transported to the mill. Both frequency and load of machine traffic were minor soil compaction problems in sugarcane fields.

Large and heavy machines have been introduced on the Island in the last few years for harvesting, loading, and transporting sugarcane. These loads are quite capable of compacting the soil under certain conditions.

Soil compaction does not influence yield directly, but it affects such vital factors as air and water movement, soil moisture, porosity, soil strength, etc. A compacted soil thus indirectly affects crop yield adversely.

Determining the magnitude of compaction caused by a particular machine or a load, and the conditions under which the compaction occurred are vital for decision making. Knowledge of soil compaction caused by different kinds of machines can help determine the one most suitable and the cultural practices to which it is best adapted.

EXPERIMENTAL SITE, MACHINES, AND PROCEDURE

Experiments were conducted on the private farm of Mr. Pedro Vivoni in Lajas Valley. Sugarcane is cultivated here at the top of a ridge.

A single row soldier-type J & L harvester[3] was used exclusively on a contract basis for harvesting all crops on this farm. These wheel-mounted harvesters weigh about 7 tons. Specifications for the front tires were 12.4-24,

[1] Manuscript submitted to Editorial Board December 5, 1973.

[2] Assistant Agricultural Engineer, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Rio Piedras, P. R.

The author is grateful to Professor Rafael Pietri Oms for the mechanical analysis of the soil.

[3] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the equipment by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment not mentioned.

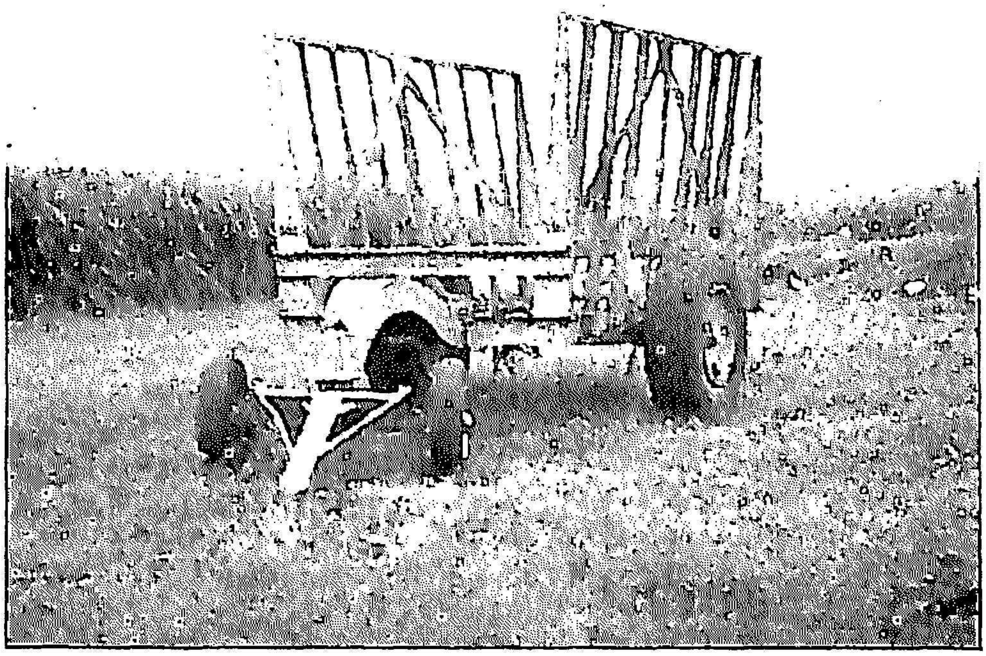

Fig. 1.—Transport unit.

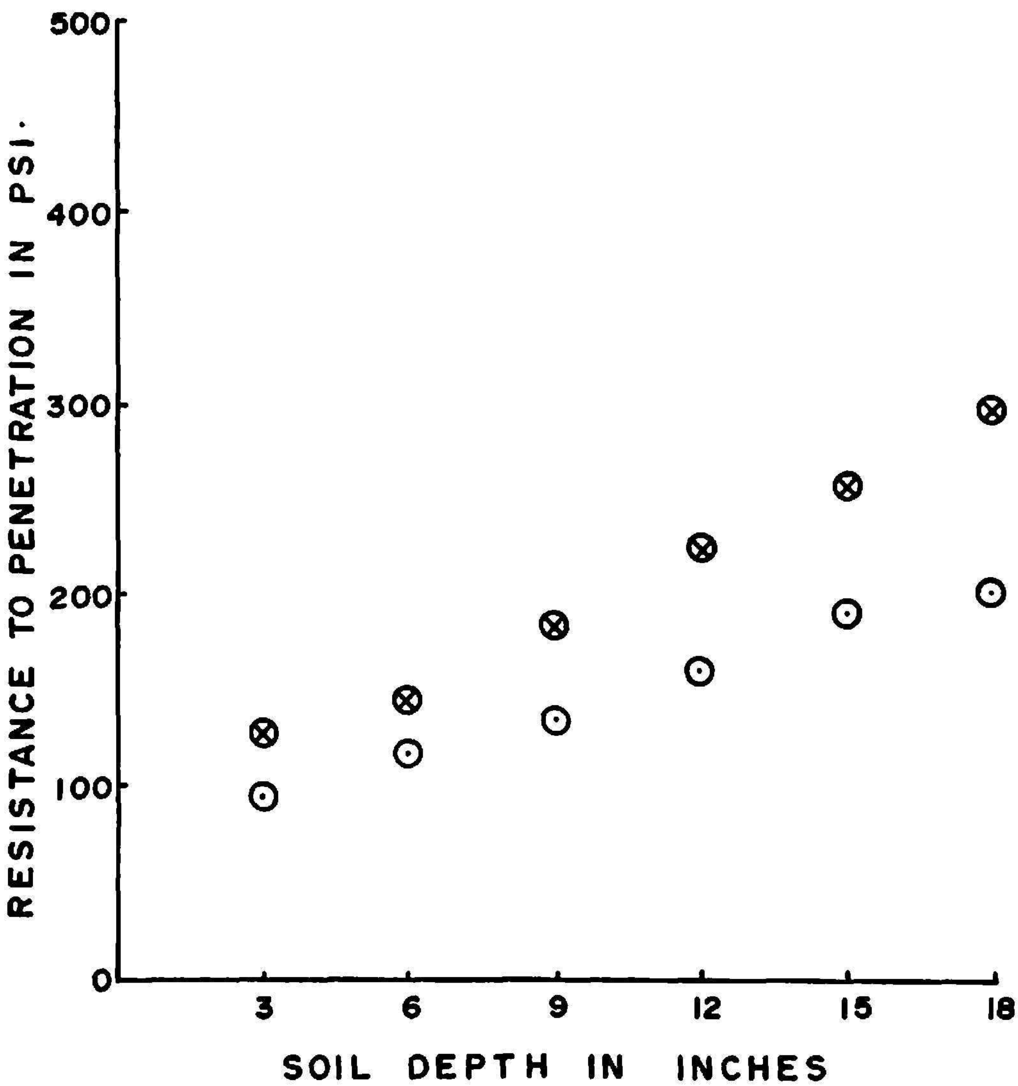

Fig. 2.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 40.99 percent in the 1st field.

8-ply rating. Front tire pressure was in the vicinity of 30 psi. Rear tire specifications were 15-30 6-ply rating. Rear tire pressure was in the vicinity of 24 psi. Rear and front tread widths were 68 and 78 inches, respectively.

A Cameco-Cane master loader owned by the Agricultural Services Administration was used for loading. Soil compaction caused by the loader was not determined. Field transport units were pulled by Minneapolis-

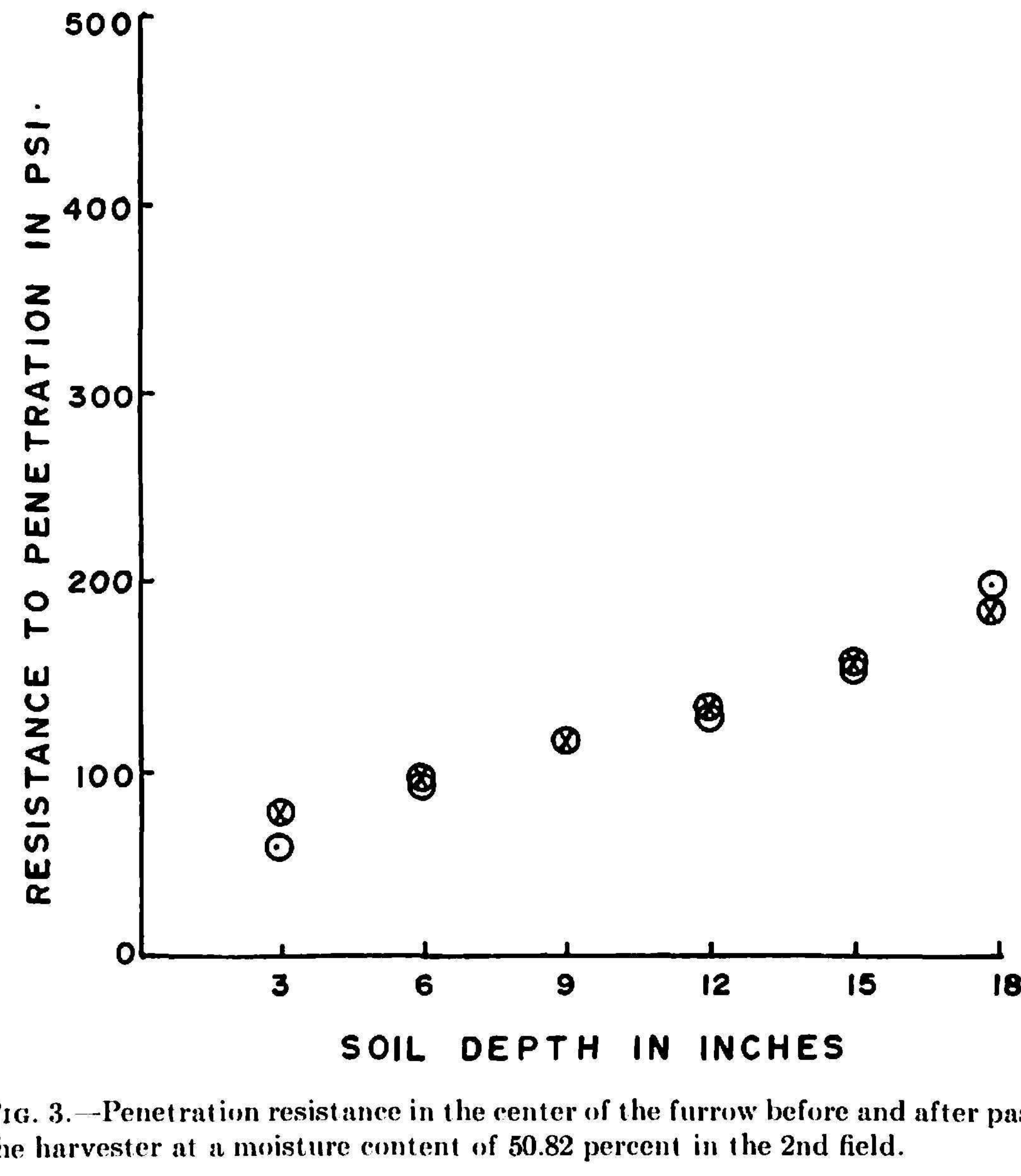

FIG. 3.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 50.82 percent in the 2nd field.

Moline tractors. Transport units (fig. 1) consisted of two 5-ton carts hitched in series. Specifications for front and rear tires of transport units were 32 × 8.8, 24-ply rating and 56 × 16, 32-ply rating, respectively. Front and rear tread widths were 54 and 91 inches, respectively. Front tire pressure was in the vicinity of 40 psi. and rear tire pressure in the vicinity of 70 psi.

This study was conducted for the purpose of determining soil compaction caused by the J & L harvester and the transport carts. Experiments were conducted in five different fields during the period March through May, 1973.

Differences in the mechanical impedance of the soil before and after passing of the load were used as a measure of its compaction. A self-recording penetrometer with a cone area of 0.2 square inches was employed for the study. The length of the driving shaft was adjustable in an increment of 1 foot.

The tires of the harvester usually passed twice in the center of each furrow. The transport cart wheels followed many patterns; two of the most usual were, either both wheels on the banks of the ridges, or one wheel on top of the ridge and the other in the bottom of the furrow.

Three sets of experiments were conducted in the first three fields. The

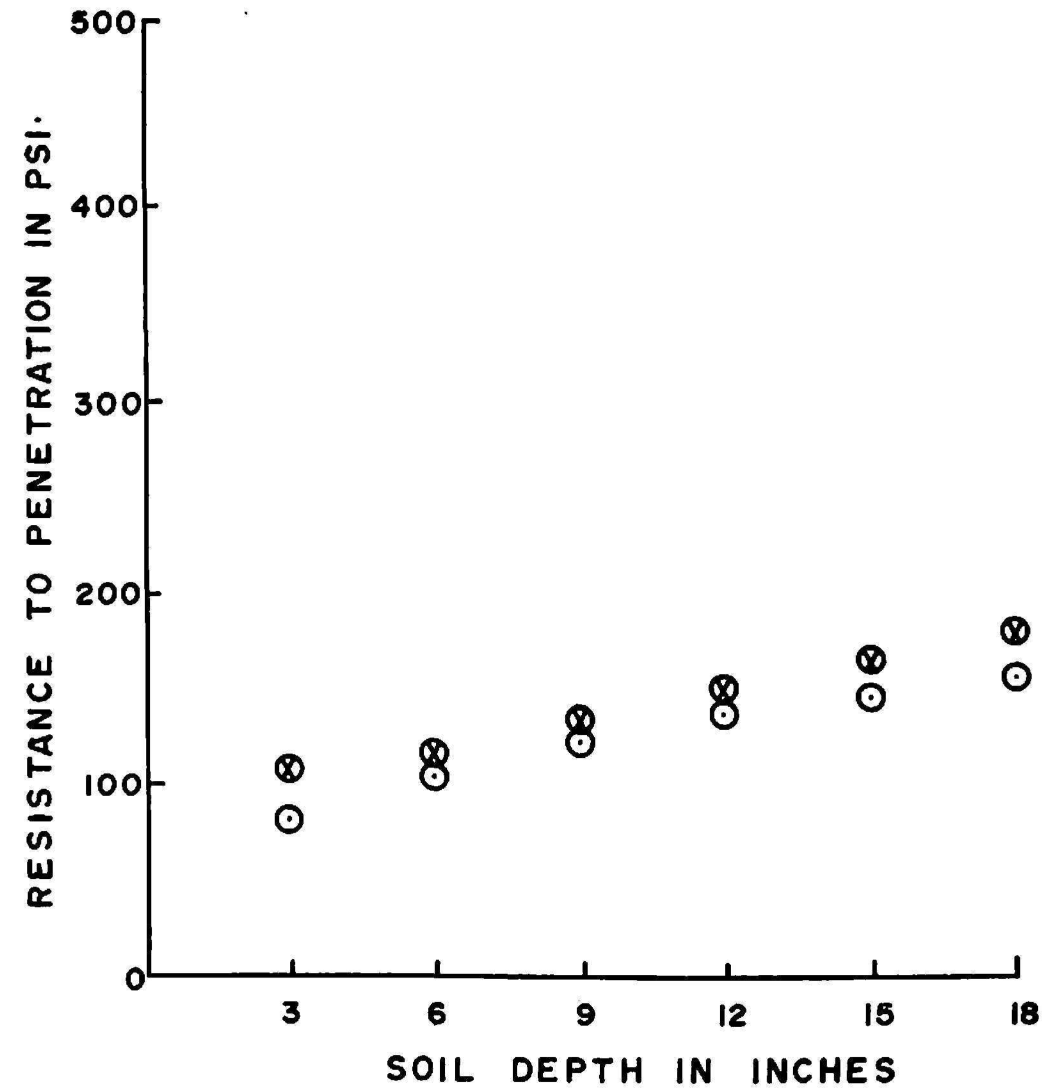

FIG. 4.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 42.67 percent in the 3rd field.

first set was to determine soil compaction caused by the harvester in the center of the furrow at a moisture content close to field capacity. The second set was to determine soil compaction caused by the harvester in the center of the furrow without altering its moisture content. The third set was to determine soil compaction caused by the loaded transport carts on the bank of the ridges without altering moisture content. Only second and third set experiments were conducted in fields 4 and 5.

For the first set of experiments, moisture at four sites was brought to field capacity by adding water slowly to the soil. The moisture content of the soil (top 3-inch layer only) for all experiments was determined by the oven-dry method.

Penetrometer readings were taken at random at the four sites, in the

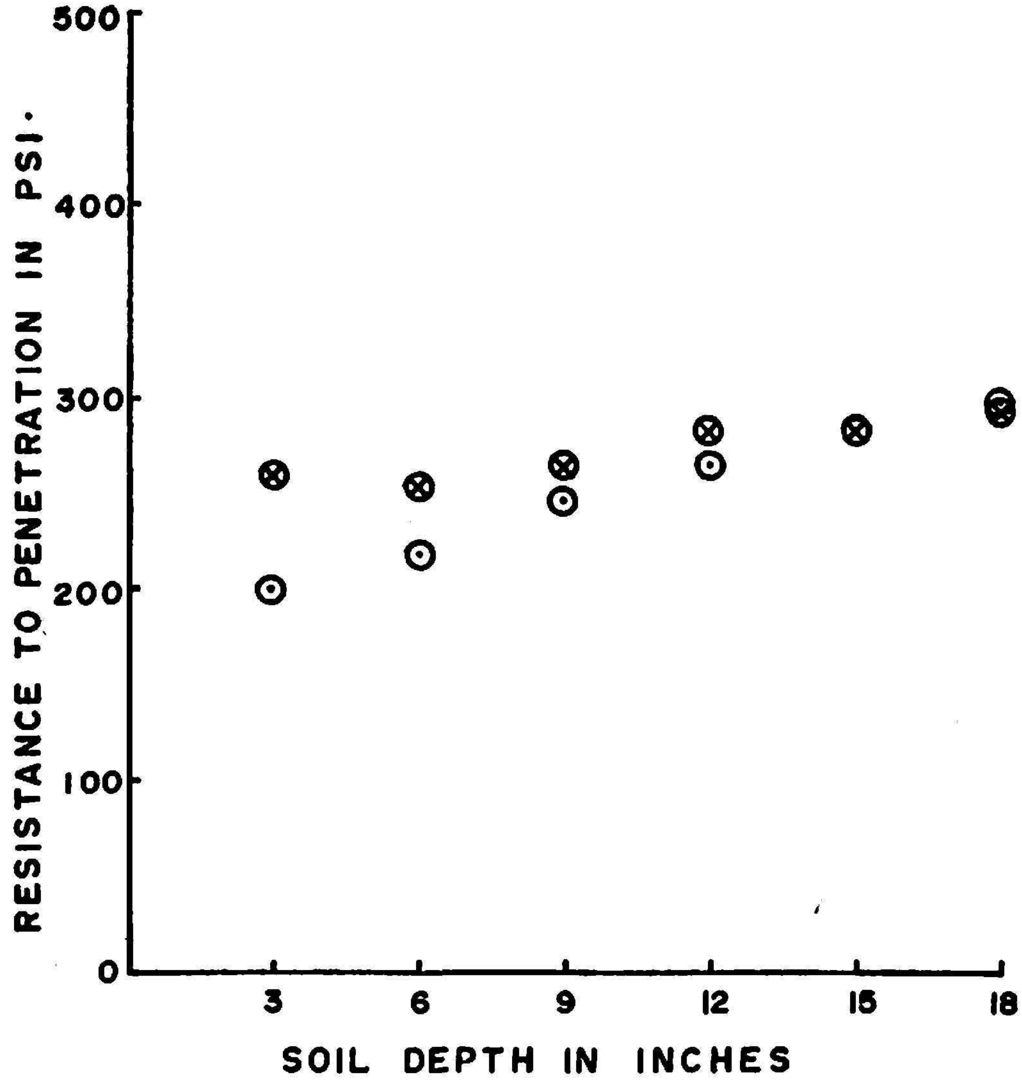

FIG. 5.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 33.48 percent in the 1st field.

center of the furrows before and after the passing of the harvester, also at random, at the bank (curving slope of the ridge) of the ridges, and before and after the passing of the loaded carts. Penetrometer output was in the form of a continuous curve (depth/penetration resistance) on a 3- × 5-inch size card.

Mechanical analyses of the soil were conducted for all five fields. Soil samples were taken from the surface to a depth of 18 inches.

RESULTS

Penetrometer outputs were analyzed for determining resistance to penetration at depths of 3, 6, 9, 12, 15 and 18 inches. The results of the analyses are plotted in figures 2 to 14. On graphs, points with a circled dot represent

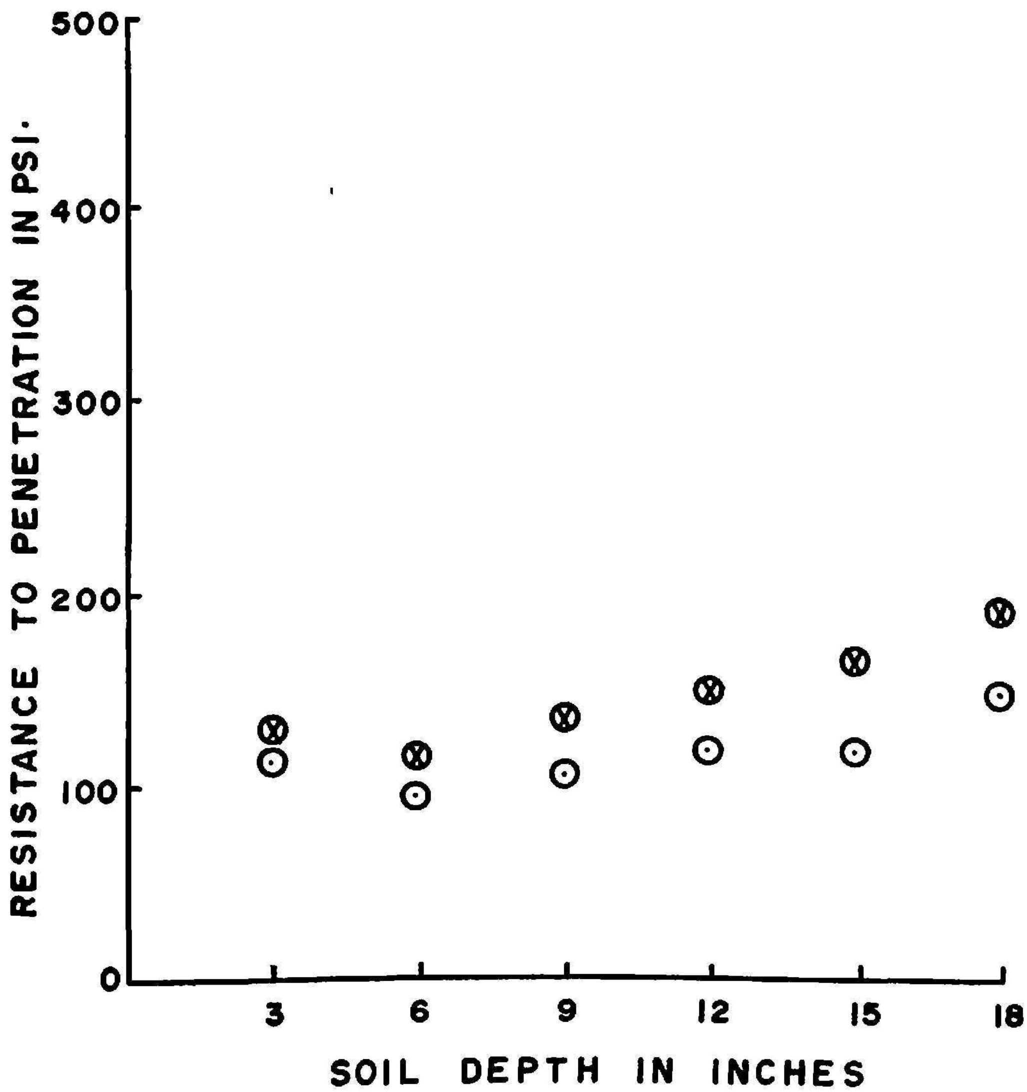

FIG. 6.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 37.25 percent in the 2nd field.

resistance to penetration before passing of the load at that depth. Points with a circled X represent resistance to penetration after passing of the load at that depth.

Figures 2, 3, and 4 show soil compaction caused by the harvester in fields 1, 2, and 3 at a moisture content close to field capacity. Figures 5, 6, 7, 8 and 9 show soil compaction caused by the harvester in fields 1, 2, 3, 4 and

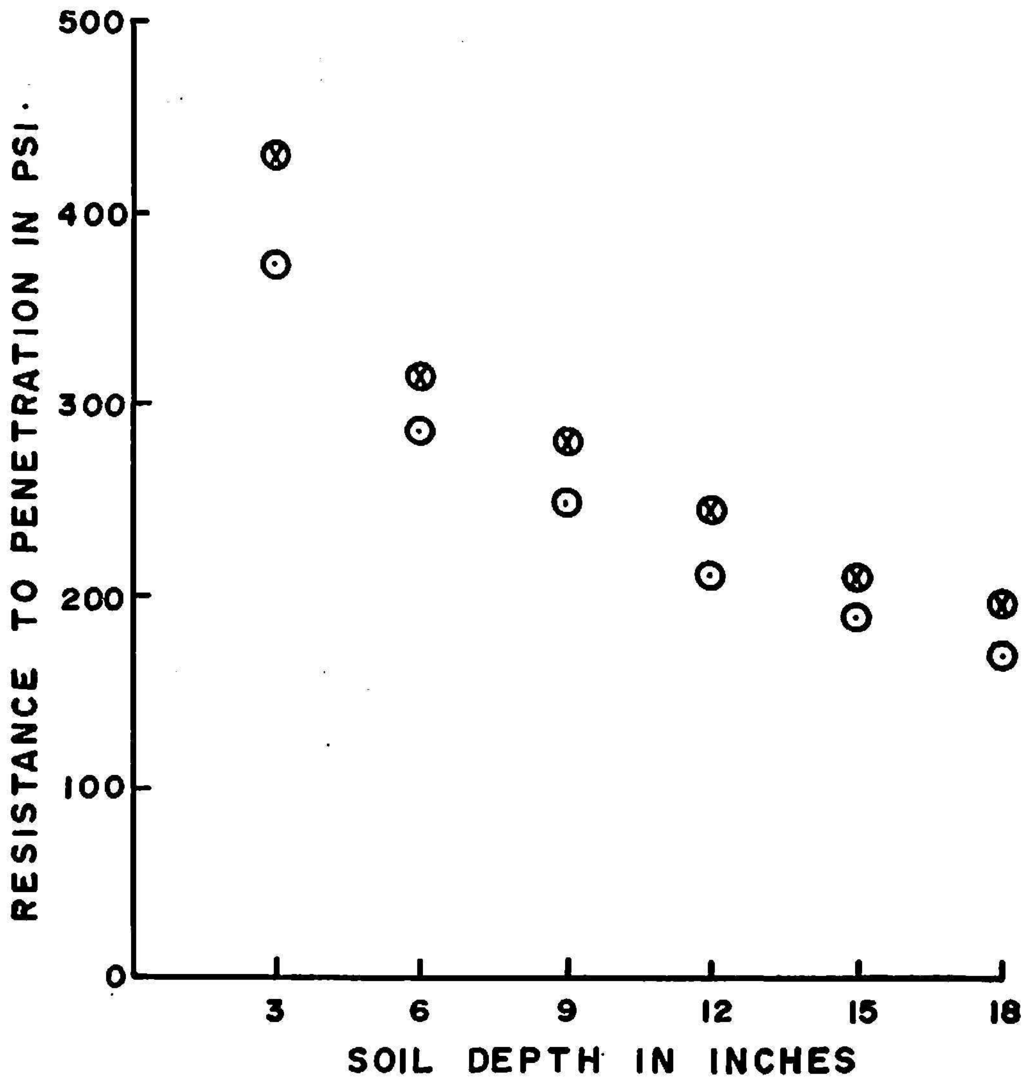

FIG. 7.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 23.66 percent in the 3rd field.

5. Soil compaction caused by transport carts is shown in figures 10, 11, 12, 13 and 14 for the five fields. Percent moisture content (dry weight basis) is indicated for each test in the legend of the graph.

An analysis of the graphs indicates that soil was not compacted heavily as a result of the harvester under the test conditions. Strong indications exist, however, of considerable soil compaction due to the loaded transport carts.

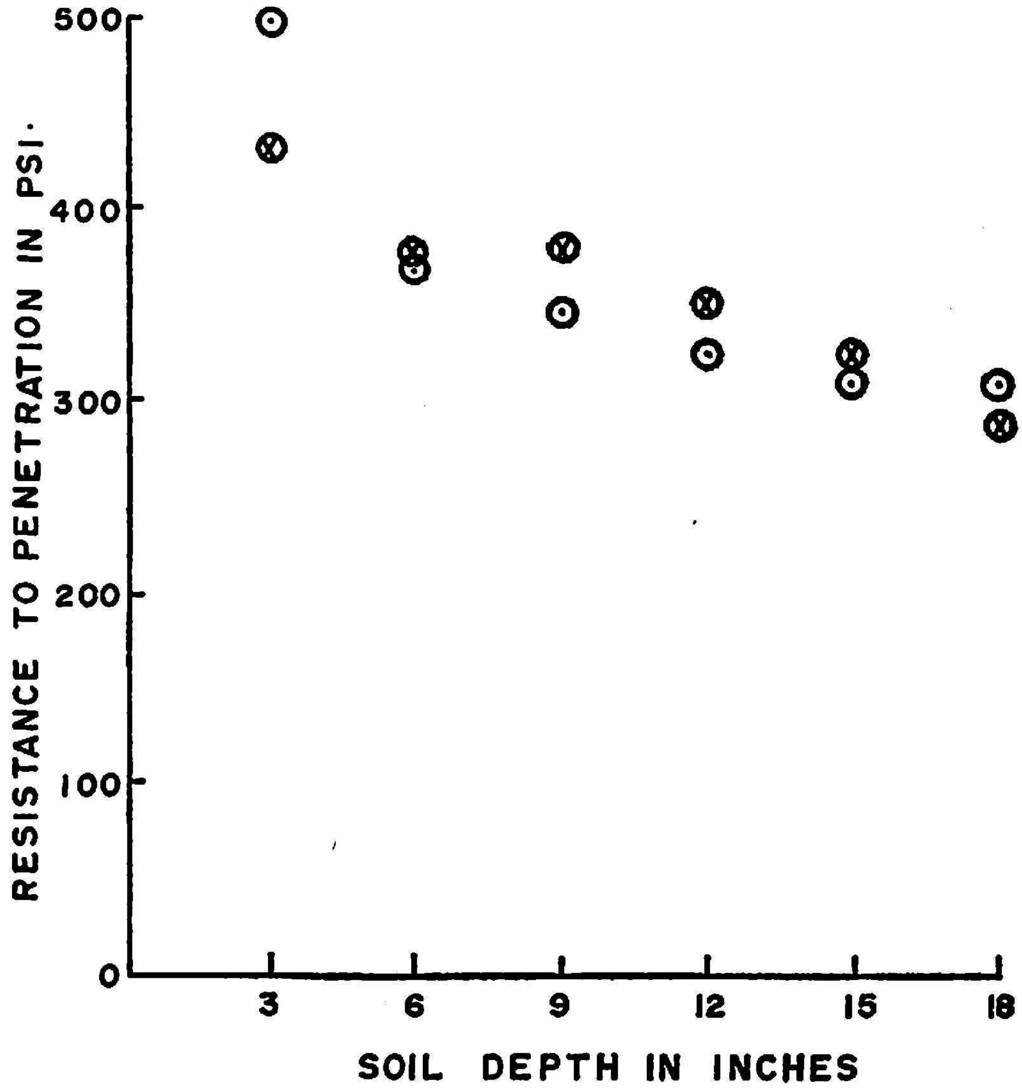

FIG. 8.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 24.14 percent in the 4th field.

Mechanical analyses confirmed the clayey nature of the soils of all five fields. The content of clay, silt, and sand varied from 54.4 to 64.6, from 12.2 to 20.0, and from 21.4 to 27.4 percent, respectively, for all fields.

DISCUSSION AND CONCLUSIONS

Soil compaction tests were conducted within the normal schedule of the farm operations to determine the magnitude of the problem. Many uncontrollable field, climatic, and management variables can alter the magnitude of soil compaction.

Mechanical impedance, bulk density, porosity and infiltration rate are four most often used indexes of soil compaction. Each has its own limitations. The penetrometer was used in this study for measuring mechanical impedance.

The magnitude of soil compaction depends on the load, pressure, moisture content of the soil, type of soil, tillage history of the soil, and many other factors. No attempt was made to correlate the effect of the different factors on the magnitude of soil compaction because it was not possible to conduct a controlled study in the field.

Penetrometer readings depend on soil compaction, moisture content of the soil, type of soil, and many other factors. There is a marked difference between the soil compaction readings of figures 2, 3 and 4. This probably was because the soil moisture had not yet stabilized. It was not possible to apply enough water and allow the time for moisture stabilization in the first field due to a sudden change in the harvesting schedule. It is possible that soil moisture below 6 inches was lower and in the range most susceptible

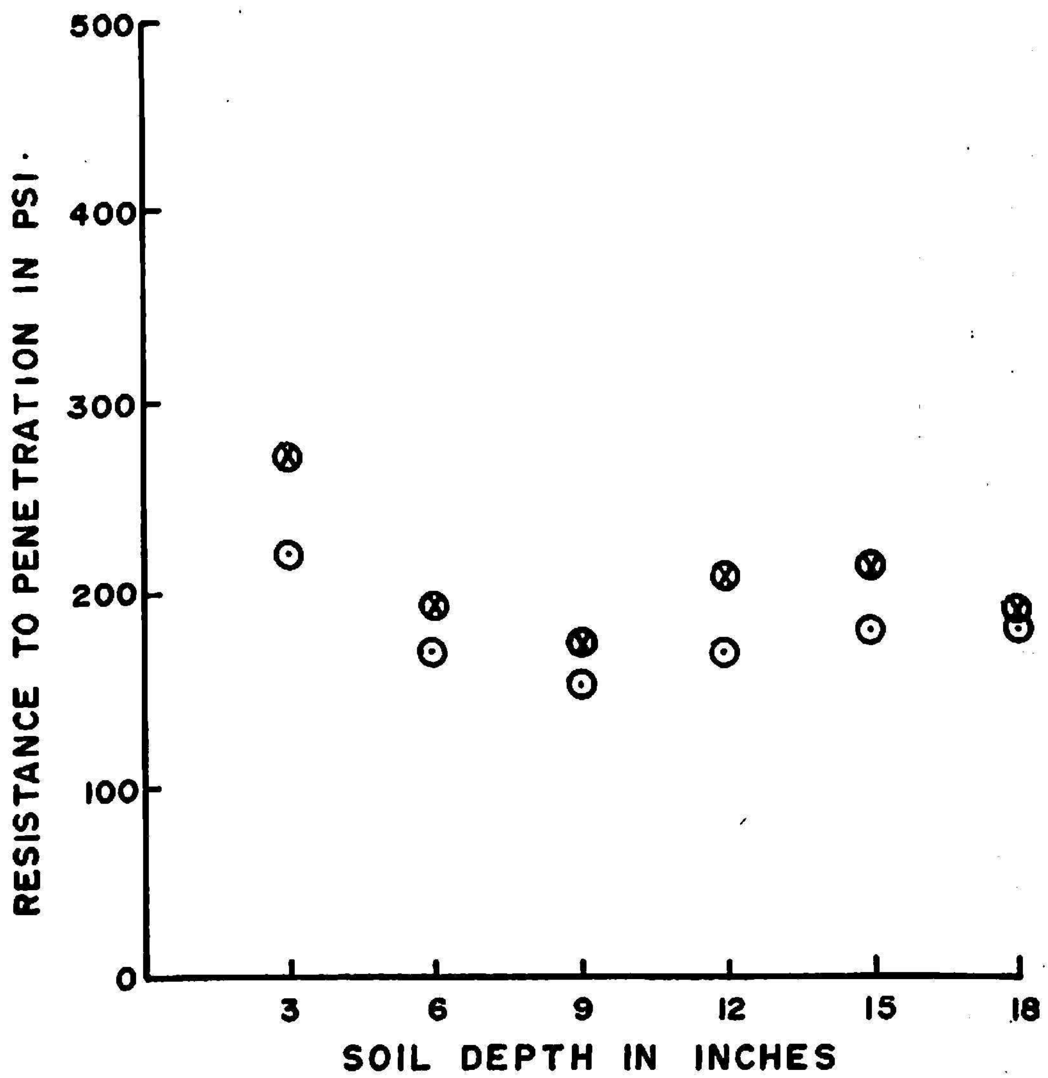

Fig. 9.—Penetration resistance in the center of the furrow before and after passing of the harvester at a moisture content of 29.76 percent in the 5th field.

to compaction. Presence of a relatively large number of stones of different sizes in the field could also have contributed to the difference.

Moisture content on the bank of the ridges always was lower than in the center of the furrow in the same field. In most instances, soil in the center of the furrow had formed a structure at harvesting time which could stand a load better than the soil on the bank of the ridge.

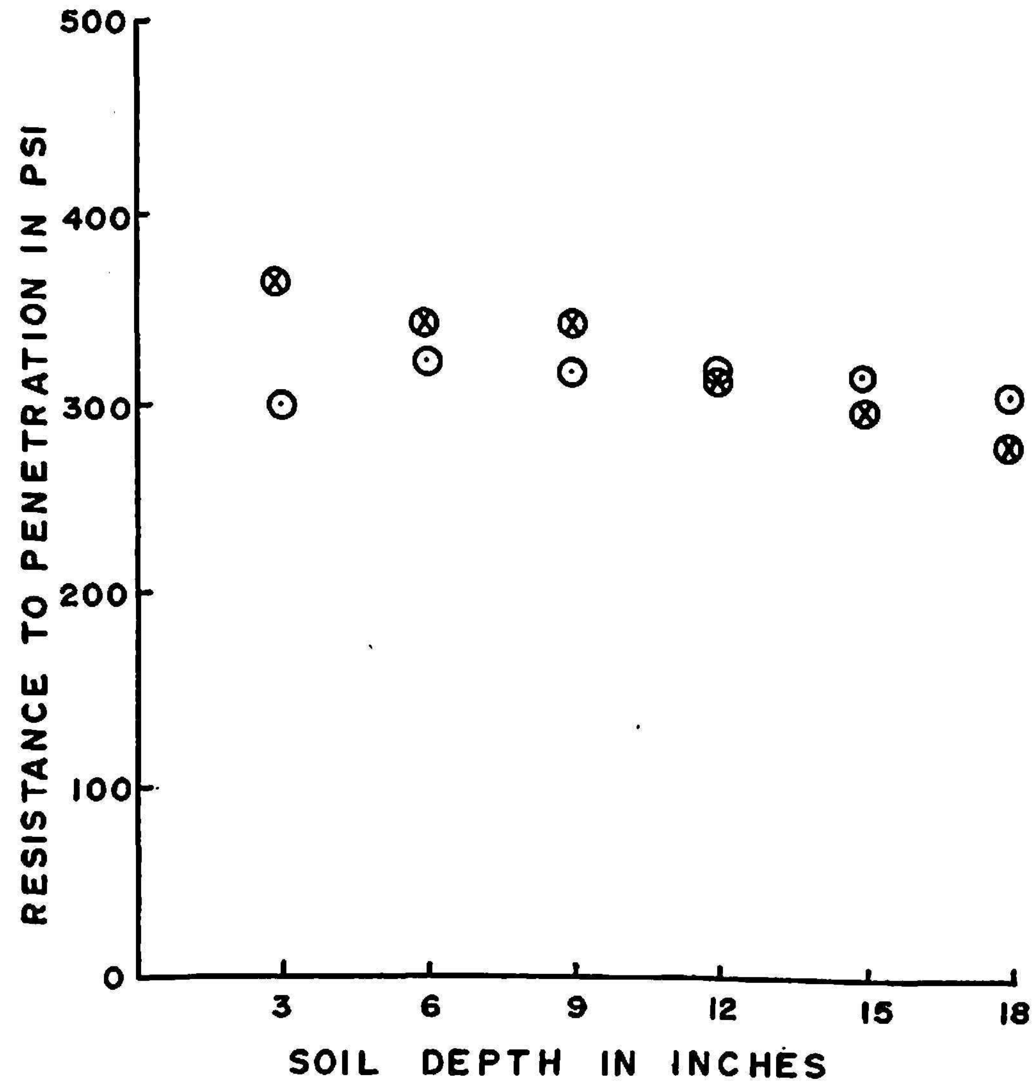

FIG. 10.—Penetration resistance on the bank of the ridge before and after passing of the loaded cart at a moisture content of 30.43 percent in the 1st field.

The soil compaction caused by the harvester under the conditions of the test measured comparatively low. A point of special interest is the resistance to penetration at the 3-inch depth in figure 8. At this depth, resistance to penetration was higher before than after passing of the machine. This probably was due to a change in the soil fabric. D. R. Freitag[4] reports "there is a

[4] Compaction of Agricultural Soils, an ASAE Monograph, 70–72, Amer. Soc. Agr. Eng., St. Joseph, Mich., 1971.

regular increase in penetration resistance and density with an increase in compaction effort; however, a point is reached beyond which the density does not increase, but the penetration resistance decreases. The change in the density-penetration relation reflects a change in the soil fabric." Also, the highest resistance to penetration for all the experiments before or after the passing of the load occurred at this point; that is, before the passing of the machine.

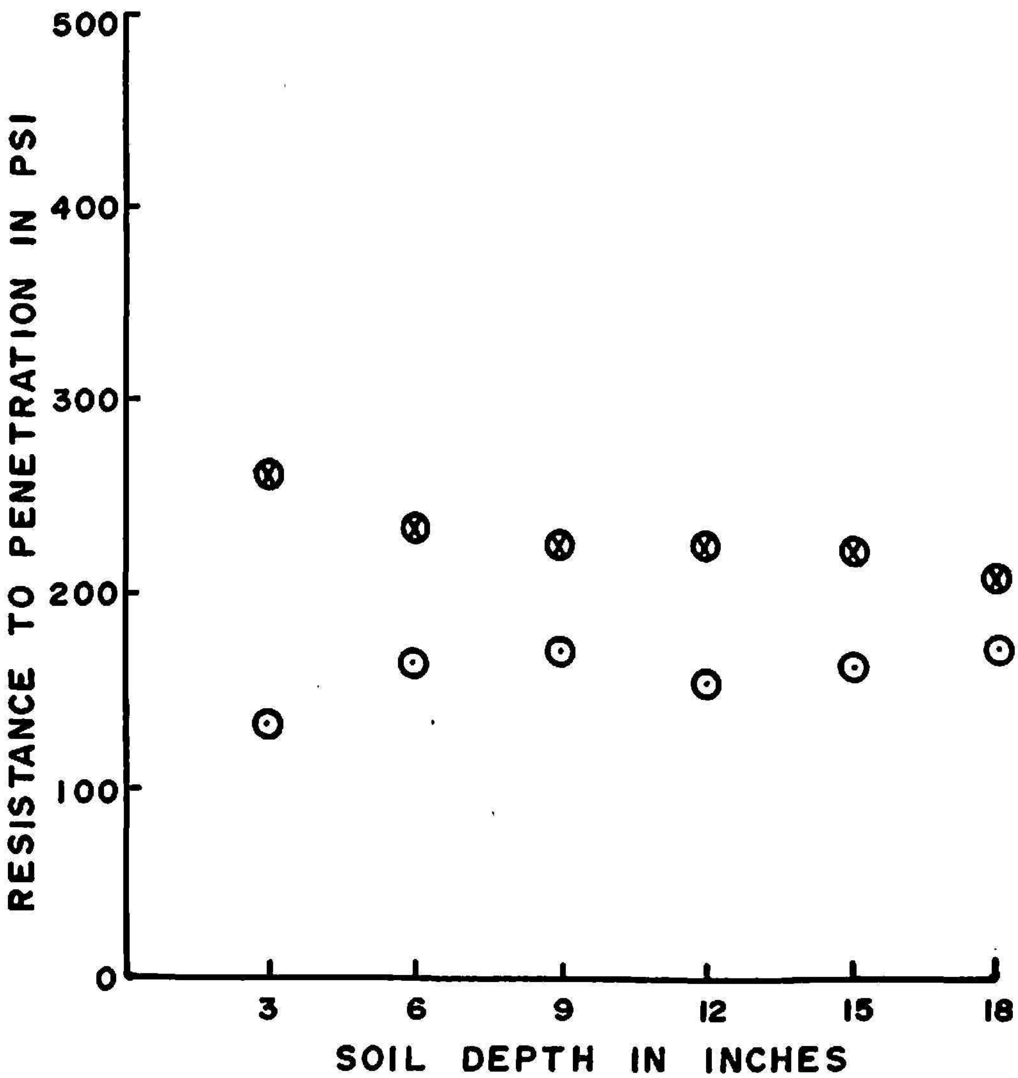

FIG. 11.—Penetration resistance on the bank of the ridge before and after passing of the loaded cart at a moisture content of 34.63 percent in the 2nd field.

Considerable soil compaction caused by the transport carts occurred in the top 1-foot layer of the bank of the ridges. This was due to load distribution. Also, the top soil in most cases was relatively loose, thus being more susceptible to compaction.

The results of the study should be interpreted with caution. They are only indicative of the problem, which should be investigated further with more control over the variables.

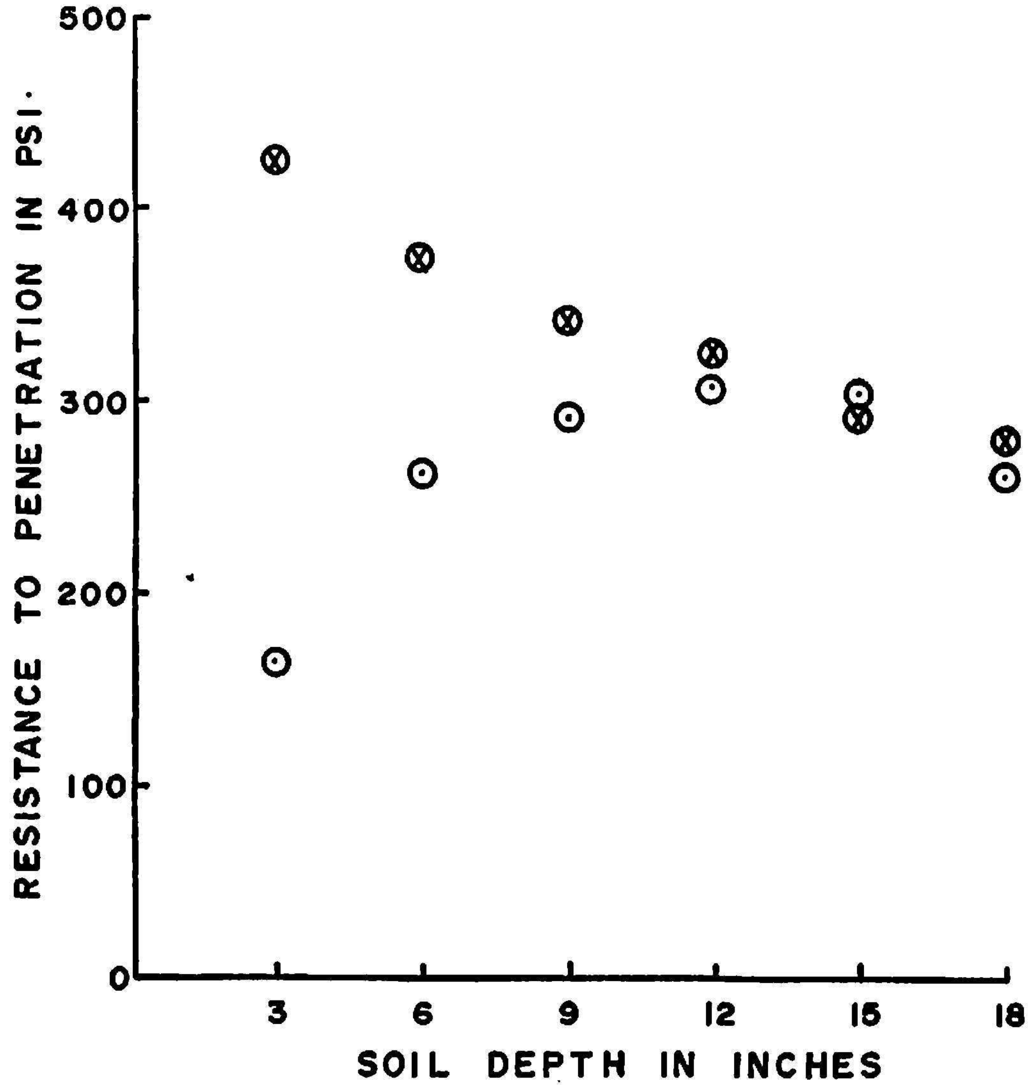

FIG. 12.—Penetration resistance on the bank of the ridge before and after passing of the loaded cart at a moisture content of 17.40 percent in the 3rd field.

Considering all pertinent factors, two conclusions can be drawn from the conditions under which the study was conducted: Soil compaction caused by the harvester was not severe and there was considerable soil compaction at the bank of the ridges caused by the loaded transport carts.

Most Lajas Valley soil is montmorillonite clay and well known for its characteristic to undo compaction when water is added. The compaction problem remains, however, until water is applied.

SUMMARY

Soil compaction tests were conducted on a farm in the Lajas Valley of Puerto Rico. Experiments were carried out in five fields of sugarcane to

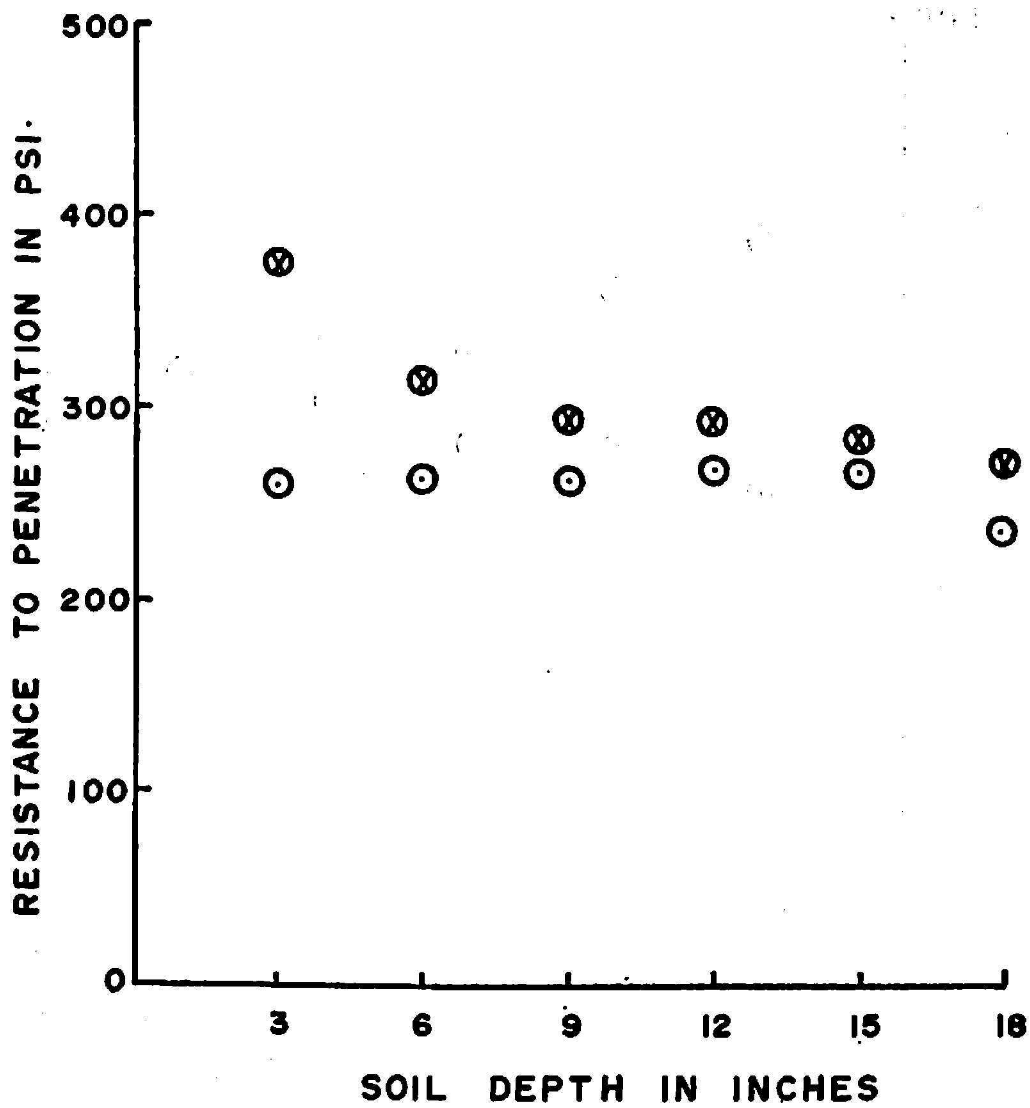

FIG. 13.—Penetration resistance on the bank of the ridge before and after passing of the loaded cart at a moisture content of 21.59 percent in the 4th field.

determine soil compaction caused in the center of furrows by a J & L harvester and in banks of ridges caused by loaded transport carts. Similar tests also were conducted in three additional fields to determine soil compaction caused by the harvester in the center of furrows at a moisture content close to field capacity.

Penetrometer readings were taken at random in the center of furrows and in the banks of ridges before and after the passing of the load. Soil moisture content was determined in these locations by the oven-dry method.

Soil compaction caused by the harvester was not severe under the conditions of the test, but the loaded transport carts caused considerable soil compaction in the bank of the ridges.

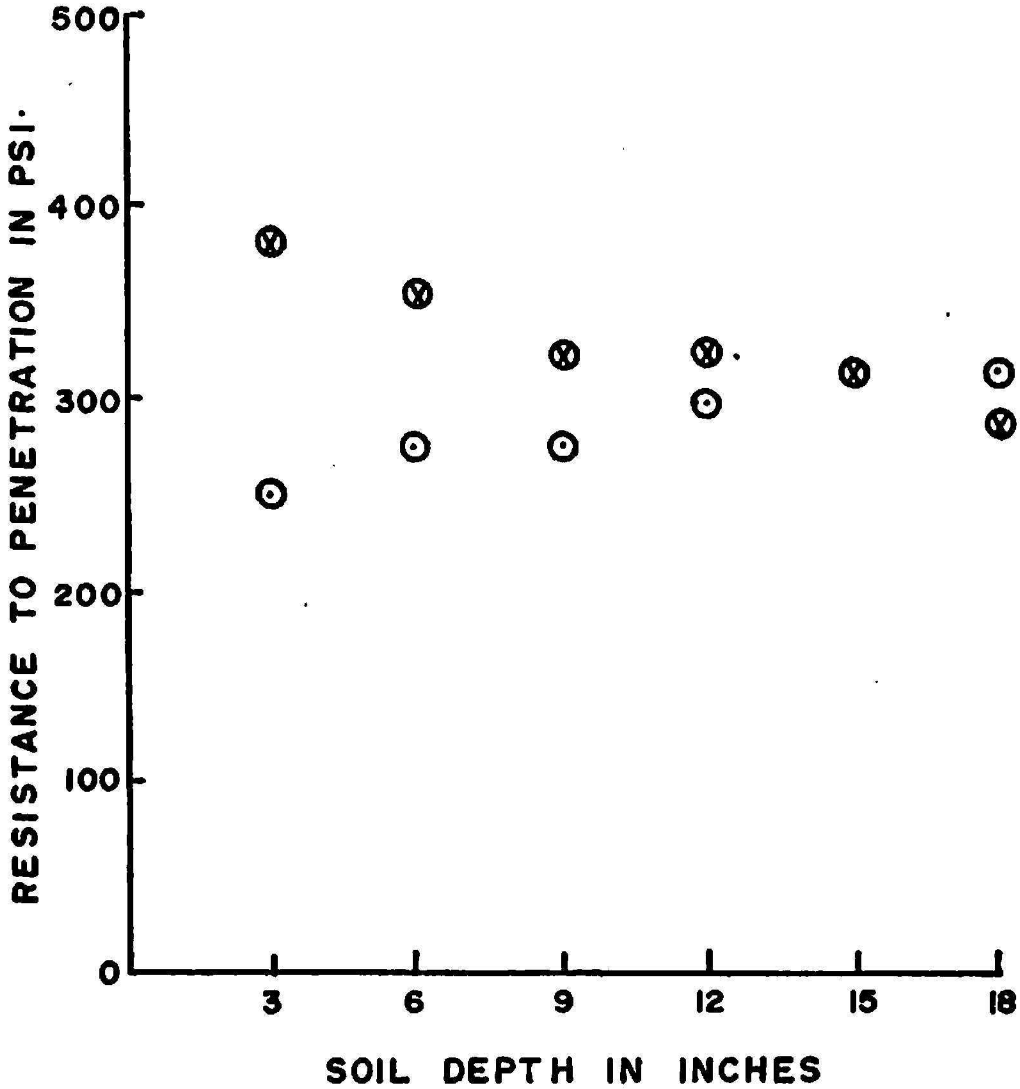

FIG. 14.—Penetration resistance on the bank of the ridge before and after passing of the loaded cart at a moisture content of 21.37 percent in the 5th field.

RESUMEN

Se llevó a cabo una serie de pruebas sobre la compactación de los suelos del Valle de Lajas en la finca del agricultor Sr. Pedro Vivoni. Se realizaron experimentos en cinco piezas distintas para determinar el grado de compactación del suelo en el centro del surco como resultado del tránsito de la cortadora J & L y en los costados del banco causada por el paso de los carretones cargados de caña. También se realizaron pruebas en otras tres piezas para determinar la compactación del suelo en el centro del surco causada por el paso de la cortadora J & L cuando el contenido de humedad del suelo se aproxima a su máxima capacidad.

Se tomaron al azar lecturas penetrométricas en el centro del surco y en el costado de los bancos antes y después de pasar la cortadora o los carretones según fuera el caso. La humedad del suelo en el centro del surco y en el costado de los bancos se determinó mediante el secado al horno.

Bajo las condiciones de las pruebas la compactación causada por la cortadora J & L no fue severa, pero se notó considerable compactación del suelo en el costado de los bancos causada por los carretones.