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Project Report

EFFECT OF ROLLING ON SOIL PACTION AND BLUEBERRY YIELD

[redacted]

AFDA Project
TDP-12

EFFECT OF ROLLING ON SOIL COMPACTION AND BLUEBERRY YIELDS

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EXECUTIVE SUMMARY

This study evaluated the effect of land rolling on the yield of blueberries, soil compaction and land levelling.

Three sites with different soil types were selected. Site 1 was located in Highland Village, Colchester county; site 2 was located in Southbrook, Cumberland county and site 3 was located in Nappan, Cumberland county. Site 1 was located on a well drained, sandy loam (Pugwash) soil, site 2 on a moderately well drained, gravelly sandy loam (Rodney) soil and site 3 on a poorly drained, loam (Kingsville) soil which was tile drained.

Land rolling was completed on two of the sites in the fall of 1988 and on the third site in the spring of 1989. In the fall of 1990, all three sites had the appropriate treatment rolled again.

Yield data was collected from each site in 1988 before rolling, in 1990 and in 1992. Individual plots at each site were hand harvested except in 1992 at site 3 which was mechanically harvested.

Land levelling was evaluated by measuring elevations of hollows and hummocks for each treatment at site 1 and 2 using land survey equipment. Measurements were collected in 1988 before rolling, 1989, 1990, and 1992.

Soil compaction was evaluated by the following methods: soil density using soil core samples, soil density using a radioactive density probe and soil penetration resistance using a cone penetrometer. Measurements were collected in 1988 (after rolling), 1989, 1990, 1991 and 1992.

Blueberry yields on the rolled treatments were reduced in the first cropping year after rolling (1990) at sites 1 and 2 only. This yield reduction, however, was not significantly different from the control treatment except for the rolled twice every 2 year treatment. In 1992, there was no significant difference in yields for all treatments at all sites.

Analyses of the soil density measurements indicate there was a significant increase in soil density at some individual depths for the rolled treatments at sites 1 and 2. These increases in soil densities were not consistent for any particular treatment or depth.

Land rolling reduced the elevation of the hummocks at site 1 for the rolled treatments. This reduction was not sufficient to allow the use of mechanical harvesters or mowers. At site 2, rolling had no significant effect on the elevations.

Growers are advised to examine alternative methods for land levelling and to use rolling as a secondary or maintenance method only.

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INTRODUCTION

Approximately 11500 hectares of land are used for blueberry production in Nova Scotia (Nova Scotia Department of Agriculture and Marketing, 1993). A significant portion of this land has a rough surface or microtopography. This has proved to be an inconvenience to producers during normal field operations such as burning, mowing and spraying. In addition, the decreasing supply of a labour force for harvesting and the increased efficiency of mechanical harvesters has producers shifting from manual to mechanical harvesting (Hall et al. 1983; Marra et al. 1989). Mechanical harvesting, however, requires nearly level fields. To level fields, producers have tried several methods such as land rolling, discing and use of excavators. In 1988, only 2 methods were being experimented with: land rolling and discing. Levelling with rollers has been proven to be beneficial to areas with minor surface roughness (Clark, 1988) but the extent of it's levelling ability is not known. In addition, the effect of land rolling on yields and soil compaction had not been examined.

Little research has been done regarding the effect of soil compaction on blueberry yields. In a demonstration project, Clark (1988) reported no direct damage to blueberry vines from an eight-ton tow behind vibrating roller. Research on the effect of soil compaction on other agricultural crops has found that soil compaction does reduce the yield of corn and alfalfa (Lowery and Schuler 1991; Voorhees et al. 1989; Meek et al. 1988). The degree of compaction required to reduce crop yields varies according to soil type and crop.

Various methods have been used to indicate soil compaction. Since soil compaction is not directly measured, researchers have measured various soil properties to establish a relationship to soil compaction. The density of soil (Meek et al. 1988), its resistance to penetration (Lowery and Schuler 1991; Voorhees et al. 1989) and its macroporosity (Carter 1990) are some properties that have been evaluated. In this project, soil density and penetration resistance were measured.

This study evaluated the effect of land rolling on the yield of blueberries, soil compaction and land levelling.

MATERIALS AND METHODS

The project was initiated in the fall of 1988 on three major blueberry producing soils in Nova Scotia. Site 1 was located in Highland Village, Colchester county; site 2 was located in Southbrook, Cumberland county and site 3 was located in Nappan, Cumberland county. The locations of the sites are shown in Figure 1.

Figure 1. Site locations.

Site 1 was located on a well drained, light sandy loam (Pugwash soil) (Webb et al, 1991). The field was considered to be very rough and not suitable for mechanical harvesting or mowing. Figure 2 shows the microtopography at site 1.

Figure 2. Microtopography at site 1.

Site 2 was located on a moderately well drained, gravelly sandy loam (Rodney soil) (Nowland and MacDougall, 1973). The site was slightly rough but not to the degree to prevent mowing. The microtopography at site 2 is shown in Figure 3.

Figure 3. Microtopography at site 2.

Site 3 was located on a poorly drained loam which was tile drained (Kingsville soil) (Nowland and MacDougall, 1973). This site was relatively level before it was rolled and therefore was used to study the effect of rolling on soil compaction and blueberry yields but not land levelling. Figure 4 shows the microtopography at site 3.

Figure 4. Microtopography at site 3.

Descriptions of the soils at each site are presented in Appendix 1.

Plot design and treatments

The plot design was a randomized block design with four treatments replicated three times at all three sites. The treatments were as follows: 1) rolled in one direction (RO), 2) rolled in two directions in 1988 or 1989 (RT), 3) rolled in two directions in 1988 or 1989 and rolled again in two directions in 1990 (RTT) and 4) control, which was not rolled (C).

The experimental sites were 1.1 hectares in area with each plot covering 0.09 hectares (400 m^2). Figure 5 shows the site layout.

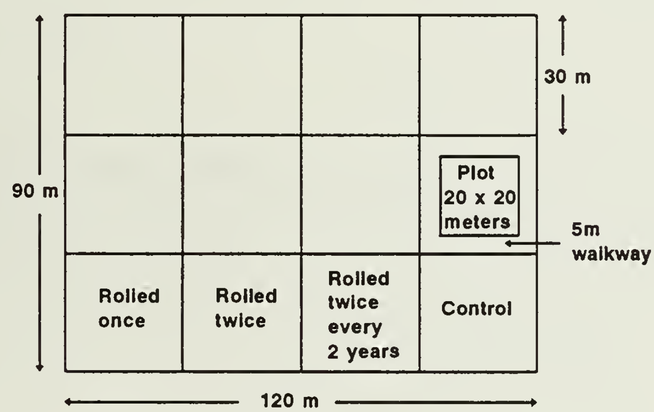

Figure 5. Site and plot design.

Site 1 and 2 were rolled in the fall of 1988 and site 3 was rolled in the spring of 1989. In the fall of 1990, all 3 sites had the RTT treatment rolled again.

The plots at site 1 and 2 were rolled with a 9 tonne, 8 feet wide roller which was pulled by 150 hp tractor. At site 3, the plots were rolled with a 5.5 tonne, 6 feet wide roller pulled by a 65 hp tractor. Figure 6 shows the roller being pulled over site 1.

Figure 6. Roller being pulled over site 1.

Land levelling

In 1988, before rolling, a detailed topographic survey of sites 1 and 2 (approximately 35 high points and 35 low points per plot for a total of 840 points per site) was completed. Each site was referenced to the Nova Scotia Grid Monument system to ensure that the measurements were based on actual grid coordinates and elevations. In 1989, 1990 and 1992 the high and low points from the original survey were located and elevation measurements were taken. There were no survey data collected at site 3 as the land surface was relatively flat.

For this report the microtopography high points are called hummocks and the low points are referred to as hollows.

The survey equipment and computer software used in the project is described in Appendix 2.

Statistical analyses (analyses of variance) was completed on the elevation differences between 1988 and 1992.

Soil density

Soil density was measured with a radioactive probe and soil cores at two sample points within each plot. One sample point was located on the top of a hummock and the other in a hollow. For each site there were a total of 24 sample points. In 1988, all plots were sampled at site 2 and nine plots at site 1. From 1989 to 1992, all plots were sampled for all sites except where noted.

Soil core samples for bulk density were taken at each sample point for the following depths: 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm and 40-50 cm (see Appendix 3 for a description of the method of analyses). A total of 210 soil core samples were collected in 1988 and between 355

and 360 per year from 1989 to 1992.

Soil density measurements were collected using the radioactive probe at 5 cm increments to a depth of 30 cm (see Appendix 3 for a description of the CPN MC-3 Portaprobe radioactive probe). A total of 504 density readings were taken in 1988 from 42 sample points. From 1989 to 1992, 864 readings from 72 sample points were taken except 1991 when 576 readings were recorded at 48 sample points with no data collected at site 3.

Measurements of penetration resistance were collected in 1988, 1989 and 1992 at all three sites at the same sample points where the soil density measurements were taken (see Appendix 3 for a description of the Rimik CP10 cone penetrometer). Due to defective equipment the collection of this data was not completed in 1990.

Statistical analyses (analyses of variance) was completed for the soil core data for 1992.

Yields

Plots at all three sites were harvested manually. Collection of yield data was supervised by members of the project team but actual harvesting was done by persons employed by the grower. The procedure for harvesting included outlining each plot with string and stringing rows within the plots. Individual rakers were assigned a row. Once a container was filled by a raker a project team member weighed the berries and recorded the yield. In 1992, ten of the twelve plots at site 3 were harvested by a mechanical harvester while the other two plots were hand raked. The number of boxes filled by the mechanical harvester on each plot were recorded and the yield was calculated using an average weight of the full boxes.

Statistical analysis (analyses of variance) was performed on the yield data from 1990 and 1992, with the 1988 yield data as the covariate.

RESULTS AND DISCUSSION

Land levelling

Elevation data were statistically analyzed for sites 1 and 2 only. The average change in elevation for each treatment from 1988 to 1992 is shown in table 1.

Table 1. Average elevation change from 1988 to 1992.

Location	Treatment	Elevation change (1988-1992) (cm)	
		Hollows	Hummock
Site 1	Control	-1.32	-4.95
	Roll once	-1.58	-9.87
	Roll twice	-1.63	-12.81
	Roll twice for 2 yr	-1.32	-15.03
	S.E. means	0.424	0.412
Site 2	Control	-4.48	-6.30
	Roll once	-4.00	-5.47
	Roll twice	-4.79	-5.50
	Roll twice for 2 yr	-4.55	-5.61
	S.E. means	0.445	0.588

At site 1, the data analyses suggests rolling did not significantly affect the land elevation in the hollow areas. However, hummocks were significantly lowered by rolling. Rolling twice in 1988 and 1990 lowered hummocks an average of 15.03 cm, rolling twice in 1988 lowered hummocks 12.81 cm and rolling once in 1988 lowered hummocks 9.87 cm. There was a decrease in elevation of 4.95 cm with the hummocks in the control treatment. This was thought to be due to natural factors such as the freeze-thaw cycle and man induced factors such as vehicle traffic (for spraying and burning). All treatments were significantly different from each other at the 0.01% confidence level.

Figures 7 and 8 show the change in elevation from 1988 (before the plots were rolled) to 1992 for plot #6 (rolled twice for two years treatment) at site 1. The vertical scale in Figures 7 and 8 has been amplified in comparison to the horizontal scale so that elevation changes would be easier to see. It is evident that the plot is smoother in 1992 (Figure 8) than in 1988 (Figure 7) but the reduction in elevation of the hummocks was not significant enough to allow for some mechanical field operations to be performed.

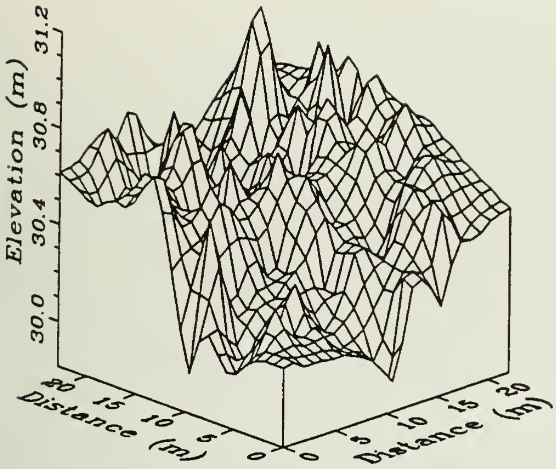

Figure 7. Elevations for plot #6 at site 1 in 1988.

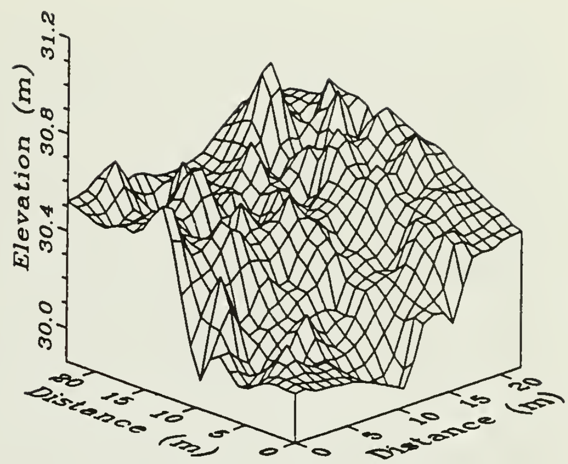

Figure 8. Elevations for plot #6 at site 1 in 1992.

It should be noted that not all of the elevation change can be attributed to compaction by the roller. Some lowering of the hummocks at site 1 was the result of the frame of the roller scrapping off the top of the hummocks. The extent of scrapping was not determined.

At site 2 there was no significant difference in elevation change among rolling treatments for either the hollows or hummocks.

Soil Density

Soil density measured with the CPN Portaprobe were very similar to values determined by the core method. Only core data were used for the soil density analysis. Average soil densities for 1992 at the three sites and for five soil depths are presented in Table 2. These data have been corrected for rock content (Sheldrick 1984).

The cone penetrometer data were so variable that any trend or pattern was not evident. The variability in penetrometer readings was due to the high stone and rhizome content found in the soils at each site. Stones and rhizomes obstruct the insertion of the penetrometer shaft into the soil and result in erroneous data.

At site 1, statistical differences between treatments were found in soil densities for different soil depths. For example, at the 20-30 cm depth for hollows, the rolled twice in 1988 and 1990 treatment had significantly higher density than the other treatments. Although the above differences occurred, the analysis did not indicate an obvious trend. In addition, some of the density differences are the result of the presence of ortsteins (cemented soil) which were found at some sample points at site 1.

Table 2. Average soil densities for 1992 at three sites and five soil depths.

Site	Depth (cm)	Hollows					Hummocks				
		Soil densities for each treatment (g/cm^3)									
		C	RO	RT	RTT	S.E. mean	C	RO	RT	RTT	S.E. mean
1	0-10	0.61	1.07	0.84	1.07	0.037	1.23	1.21	1.30	1.33	0.037
2		0.90	0.82	0.93	0.79		0.89	1.03	1.08	0.96	
3		1.20	1.21	1.17	1.31		1.21	1.17	1.24	1.20	
1	10-20	1.24	1.12	1.27	1.25	0.045	1.31	1.41	1.42	1.49	0.045
2		0.94	0.84	0.89	0.92		0.89	1.03	1.03	1.05	
3		1.46	1.58	1.39	1.50		1.46	1.43	1.34	1.48	
1	20-30	1.17	1.20	1.26	1.41	0.048	1.34	1.33	1.37	1.50	0.048
2		0.90	0.90	0.85	0.86		1.00	1.19	1.03	1.09	
3		1.48	1.60	1.49	1.40		1.40	1.47	1.49	1.48	
1	30-40	1.33	1.36	1.35	1.12	0.046	1.37	1.40	1.28	1.39	0.046
2		1.25	1.17	1.15	0.94		1.27	1.30	0.92	1.08	
3		1.65	1.68	1.65	1.68		1.68	1.65	1.69	1.59	
1	40-50	1.22	1.50	1.34	1.49	0.037	1.32	1.29	1.19	1.37	0.037
2		1.31	1.07	1.27	1.05		1.12	1.35	0.99	1.10	
3		1.80	1.69	1.70	1.69		1.71	1.71	1.69	1.65	

Treatments: C - Control, RO - Rolled once, RT - Rolled twice and RTT - Rolled twice for two years.

At site 2, there were statistical differences between treatments at individual depths but similar to site 1 there was no obvious trend in the data analysis.

At site 3, there was no significant difference in soil density measured at any soil depth for either the hummocks or hollows.

Yields

Yields were collected in 1988, 1990 and 1992 at all three sites. The 1988 yield data were collected before the initial rolling treatments. The yield data presented in Tables 3 and 4 has been statistically adjusted for the covariate (1988 yields).

Table 3. 1990 yields adjusted for covariate.

Location	Yield (kg/ha) per treatment				S.E. means
	Control	Roll once	Roll twice	Roll twice for 2 yr	
Site 1	694	565	515	499	111.3
Site 2	480	251	270	176	
Site 3	482	484	624	557	

Table 4. 1992 yields adjusted for covariate.

Location	Yield (kg/ha) per treatment				S.E. means
	Control	Roll once	Roll twice	Roll twice for 2 yr	
Site 1	560	491	434	469	60.6
Site 2	291	215	326	208	
Site 3	278	289	334	319	

In 1990, at site 2, the yields from the rolling twice in 1988 and 1990 treatment were significantly lower than the control treatment at the 0.05% confidence level. There was no significant statistical difference in yields among any of the other rolling treatments in 1990 although the yields at sites 1 and 2 from the three rolling treatments were lower when compared to the control treatment. Some yield reduction from the three rolling treatments at site 1 can be attributed to the roller frame scrapping off the hummock tops.

Yields from the second cropping year after rolling (1992) for the rolled treatments improved as they were only marginally lower than the yields of the control treatment. There was no significant difference in yields among treatments for the 1992 season.

CONCLUSIONS

There was a decrease in blueberry yields in the first cropping year after rolling (1990) for the treatments that were rolled. This occurred at sites 1 and 2 but the decrease was not statistically significant. In the second cropping year (1992) the blueberry yields on the rolled treatments improved and were only marginally lower than the control treatment. There was no reduction of blueberry yields for the rolled treatments at site 3 for either cropping year.

Soil density measurements indicate there was a significant increase in soil density at some individual depths for the rolled treatments at sites 1 and 2. These increases in soil densities were not consistent for any particular treatment or depth.

Land rolling did marginally level the land at site 1. Elevation of the hummocks in the rolled twice in 1988 and 1990 treatment was reduced by 10 cm compared to the control treatment. Not all of this levelling, however, can be attributed to compression by the roller as the frame of the roller scrapped off some tops of the hummocks. The reduction in elevation of the hummocks at site 1 was not sufficient to allow for some mechanical field operations to be performed. This was also true at site 2, where rolling had no significant effect on the microtopography.

Growers are advised to examine alternative methods for land levelling. Land rolling does not level fields to the extent that mechanical harvesters can be used. Land rolling should only be used to smooth the fields much the same way homeowners roll their lawns. It is not recommended growers roll every 2 years as the cumulative effect of rolling may prove to be detrimental to the blueberries.

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APPENDIX 1

Analysis of Soils at each Site

SITE 1

Nine sites were examined at this site. The soils were classified dominantly as a well drained, deep, sandy loam of the Pugwash series. Some inclusions of well drained, sandy loam Pugwash ortstein phase were also found.

Table 5. Description of the soil at site 1.

Horizon	Depth (cm)	Description	% Sand	% Silt	% Clay
Ah	0 - 4	Very friable, sandy loam	75.6	19.4	5.0
Bf	4 - 37	Friable, sandy loam	65.1	31.3	3.6
Bm	37 - 60	Friable, sandy loam	64.3	32.8	2.9

SITE 2

Nine sample sites were examined at site 2. The soils were classified as a moderately well drained gravelly silt loams of the Rodney series.

Table 6. Description of the soil at site 2.

Horizon	Depth (cm)	Description	% Sand	% Silt	% Clay
Ah	0 - 3	Friable, gravelly silt loam			
Bf	3 - 30	Friable, gravelly silt loam	40.8	50.8	8.4
Bm	30 - 60	Friable, gravelly silt loam	48.6	42.0	9.4

SITE 3

Nine sites were sampled at this site. The soils were classified dominantly as a poorly drained silt loam over clay loam Kingsville soil.

Table 7. Description of the soil at site 3.

Horizon	Depth (cm)	Description	% Sand	% Silt	% Clay
Ah	0 - 3	Friable, silt loam	31.9	55.9	12.2
Bg	3 - 31	Friable, sandy loam	31.5	48.2	20.3
Cg	31 +	Firm, clay loam	24.2	46.4	29.4

Methods of analysis for the samples taken from the sites examined during the survey are indicated below with the method number corresponding to the number in the manual by McKeague (1978):

Particle size analysis: Method 2.11
Organic carbon: Method 4.22
Bulk density: Method 2.214

APPENDIX 2

Description of Equipment used for the Measuring Land Elevation

The equipment used in the field to locate and record elevations of the hummocks and hollows of each plot is listed below:

Wild T-1000 Electronic Theodolite
Wild DI5-S EDM (Electronic Distance Measuring Device)
Wild GRE-3 Data Collector

The field data was processed with Wild survey software (TOPOS) and all plans were generated with drafting software (AutoCad) on an IBM AT-style clone computer and plotted on a Zericon plotter.

APPENDIX 3

Methods for Measuring Soil Compaction

CPN MC-3 Portaprobe.

The device operates by emitting gamma radiation into the soil. Some gamma radiation will pass through the soil and be detected by the detector in the Portaprobe. A high density soil will absorb more gamma radiation than a low density soil.

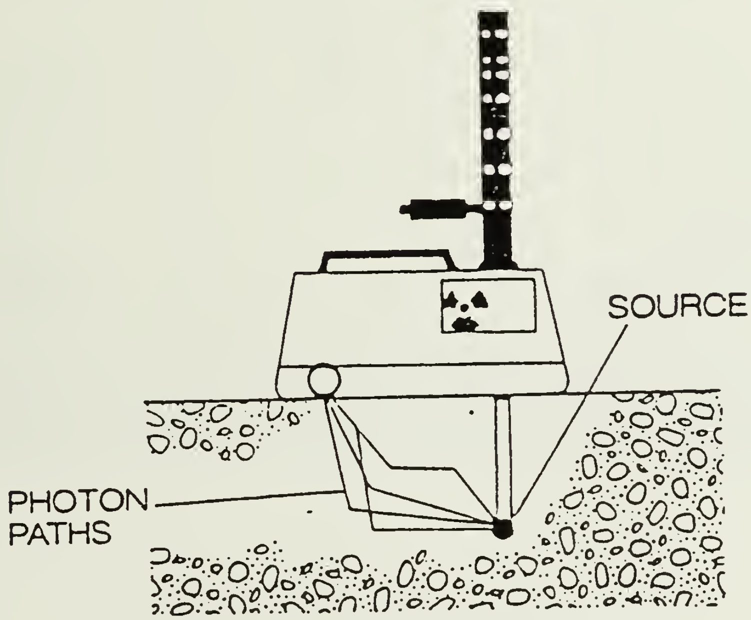

Figure 9. CPN MC-3 Portaprobe.

Bulk density as determined by cores.

Method 84-029 as described by Sheldrick (1984) was used to determine bulk density from the soil cores that were collected.

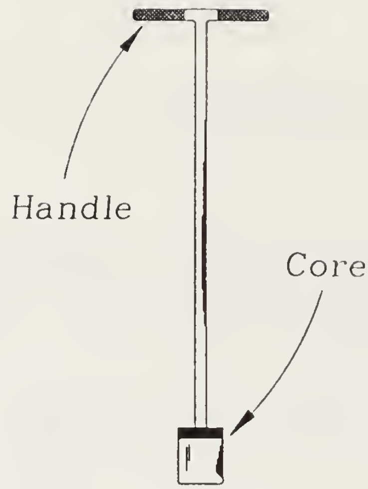

Figure 10. Soil core sampler.

Rimik CP10 cone penetrometer.

The Rimik CP10 is a cone penetrometer and a datalogger with 64k of data storage memory. To operate the Rimik CP10, slowly push the probe into the soil to a depth of 450 mm. Then withdraw the probe and move to the next site. The data is automatically saved on the datalogger.

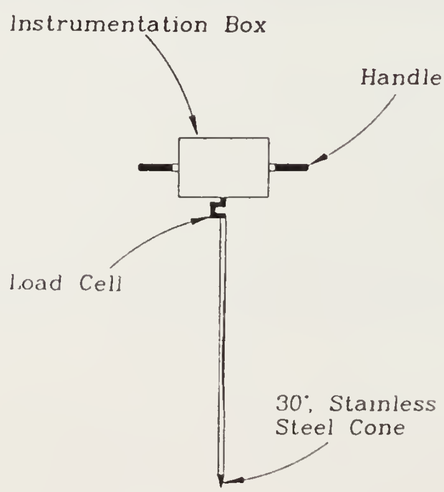

Figure 11. Rimik CP10 cone penetrometer.