International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(4): 478-483

https://www.mathsjournal.com
Received: 02-05-2023
Accepted: 03-06-2023

Vinay Kumar
Research Scholar, Department of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author:
Vinay Kumar
Research Scholar, Department of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana, Punjab, India

Prediction of hardpan zones in the soil profile using field scout SC 900 cone penetrometer

Vinay Kumar

Abstract
Many numerical techniques and methods are being used in engineering applications, and digital computers are very useful to assist manufacturing and design engineers. There is growing recognition of the importance of soil compaction, but the cost of the tool, the frequency of measurement, and the interpretation of the data limit its measurements in agriculture. The hand-held push-type cone penetrometers are commonly used in tillage management and off-road traffic research as an indicator of soil hardness, density, and strength characteristics related to the engineering properties of the agricultural soil. A study was carried out to predict hardpan in the soil profile with the help of Field Scout SC 900 Cone Penetrometer that follows American Society of Agricultural Engineers standards. The device consists of a power transducer to measure the forces of penetration, ultrasonic depth for measuring sensors and a data recording system to amplify, digitize and collect data.

Keywords: Cone penetrometer, hand-pushed penetrometer, cone index, megapascal, data logging system, load cell

1. Introduction
The cone permeameter is the simplest and simplest tool recommended for determining soil osmotic resistance, including the drive shaft and cone (Lowery and Morrison 2002) [5]. Penetration resistance is expressed as a function of the pressure or opposite force provided by the soil when the cone penetrates the soil. The force required to penetrate the conical probe vertically into the soil divided by the cross-sectional area of the cone top surface is called the cone index (CI), which is called the soil pressure index, expressed in kilopascals (kPa) or megapascals (MPa). The value of the cone index is influenced by many factors, such as the shape and size of the cone, the roughness of the surface, and the rate at which the probe is introduced into the soil (Aubertot *et al.* 2002) [1]. The first manual cone penetrator to measure soil strength with a cone index (CI) was developed by Hendrick in 1969. The system had a wide range of adaptability and flexibility to quickly record soil stress, making it a valuable and reliable tool for agronomists. This led to the development of new and improved instruments along with electronic tools to monitor penetration resistance using load cells and depth penetration depth with depth sensors.
Data logging devices and control panels are also gradually being introduced by various researchers into new versions of penetration indicators (Torres and Saraiva 1999) [7]. Therefore, for the uniformity and convenience of soil stress test results, the American Society of Agricultural and Biological Engineers (ASABE 1998) [2] has developed some standards for cone size and penetration rate. The standard includes drive shafts with a smaller diameter to reduce the impact of friction on the outside of the shaft and stainless-steel cones with an upper angle of 30 degrees. Before penetration testing, the contact indicator is first set to zero, and when the probe penetrates the soil at a uniform rate of about 30 mm / s, the contact indicator readings are recorded every 2.5 cm from the axis of penetration.
Penetrometers are also distinguished according to the method used to record penetration resistance. One penetrates vertically into the soil and the other moves horizontally. The horizontally conical tip is supported by a group rod mounted on the tractor's three-point backlink system, connected to a load cell, and continuously records soil infiltration. The subsurface moving parts of these horizontal penetrators are subject to significant forces and are

often subject to severe wear and corrosion due to friction between the penetration probe and soil particles. In contrast, a penetrometer operating vertically does not have the complexity described above, since it only performs separate measurements. In addition, many researchers have improved the vertical tapered penetration gauge (Alimardani 2005) [3] by adjusting it to a three-point fastening system with an improved version of the hydraulic operating system.

Over the past two decades, researchers and manufacturers have developed a variety of automated hydraulically operated soil profile sensors that incorporates different geometric shapes of probes and shafts, operate at different speeds beyond the standard, and integrate other sensors into the terminal, such as sensors measuring humidity, temperature, and conductivity (Sun *et al.* 2006) [6]. According to Kumar and Bector (2022) [8], various types of soil sensors can directly or indirectly monitor soil compaction based on the characteristics of the sensor type such as contact sensors, and non-contact sensors, and combined with other sensor systems, as shown in the flowchart (Fig. 1).

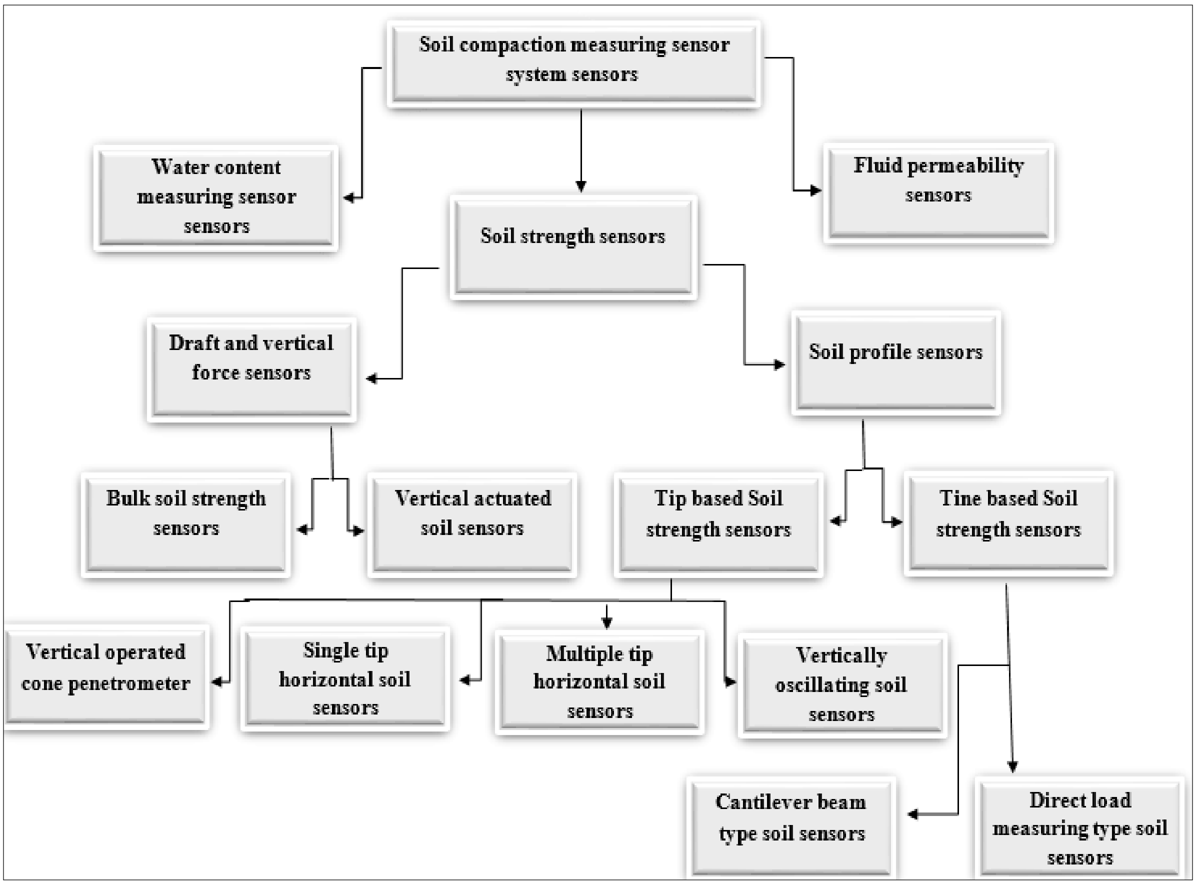

Fig 1: Classification of different types of soil compaction monitoring sensor systems

2. Materials and Methods

2.1 Study site

Kharar is a town and municipal council in the district of Mohali, Punjab, India. It is located near the city of Mohali city. Kharar is located at 30°44′N 76°39′E / 30.74°N 76.65°E and has an average elevation of 309 meters (1,014 ft). The location of the study area is shown in Fig. 2 and Fig. 3.

Fig 2: Study location of the experimental site (Kharar in Punjab, India)

Fig 3: Google map showing the location of the experimental site

2.2 Brief Description and Working Mechanism of The Field Scout Sc 900 Cone Penetrometer

2.2.1 Description

This electronic Field SC 900 Cone Penetrometer is the most versatile compaction measuring instrument in the market. The soil depth reading is determined by the acoustic depth sensor. The value of the cone indicator is measured by the force sensor and is displayed as PSI or kPa. This is a state-of-the-art digital cone penetrator for the measurement of soil density and compaction studies. This digital soil compaction equipment measures soil hardness as cone index data, records the data, and allows users to view the data to make soil management decisions. The mounted shaft of the field scout probes allows users to make many measurements easily and quickly. Probes are available with a 1/2" or 3/4" diameter of the conical tip. The shaft can be divided into 2 parts, which are convenient for storage and transportation. The ultrasonic waves at the bottom of the meter are used to measure the depth of visual penetration extending approximately 30 degrees from the axis. The view of the Field SC 900 Cone Penetrometer is shown in Fig. 4.

Fig 4: Field SC 900 Cone Penetrometer

2.2.2 Mechanism

Turn on the meter power switch to turn the meter/data logger on and off. When the meter is turned on, it will show the battery status for 3 seconds. If the logger is enabled in the program, in the next 3 seconds, it will show the memory usage of the logger and whether a GPS signal has been found. If a GPS signal is found, it will automatically include latitude and longitude data in the data file. If the data forest is turned off, no data will be stored in the meter and the above Logger/GPS screens will not be able to get around during the start-up. The countdown will reach its first operating screen after completing the start-up procedure. From the first operating screen, the START button will enter the countdown to the countdown mode and the LCD will be displayed. Then the count will be ready to take the readings. After the profile is measured, the REVIEW tuning allows the user to see the value of the cone pointer at every depth. At the push of a button, the show is consistently scrolling throughout the profile. The built-in counter detective can record multiple location data and eradicates the need to manually record data. Through the program, the user can upload data, and change data load settings and counter configuration.

2.3 Measurement of soil compaction by cone penetrometer at different geographical reference

The Field Scout SC 900 soil compaction meter was used for measuring cone index at the Kharar district of Mohali in Punjab, India. The experiment was conducted after the harvest of the paddy crop in Sandy Loam soil as shown in Fig. 5. The mean bulk density and moisture percentage were 1.64 Mgm^{-3} and 11.23%. A plot of 0.5 hectares was selected for the study and divided into 4 blocks (1200-meter square each). A total of 36 samples were randomly recorded which means 9 samples were recorded from each grid size of the 1200-meter square (P1, P2, P3, P4, P5, P6, P7, P8, P9) at an interval of 2.5 cm. The mean of each grid was calculated and plotted in the graph for comparison of the mean with and within the blocks. The specification of the Field Scout SC 900 soil compaction meter is shown in Table 1. The Field Scout SC 900 soil compaction meter recorded the soil profile data required for penetration of the cone inside the soil profile along with date, time, and real-time GPS coordinates. This provided an easy graphical representation of the hardpans in the soil profile at an interval of 2.5 cm by plotting it against depths up to 60 cm. Additionally, the penetration rates selected for the study constantly monitor the penetration rate and at the same time, the user displays real-time data on the screen to instantly interplay the result.

Table 1: Specifications of the Field Scout SC 900 Cone Penetrometer

S. No.	Particulars	SC 900 Cone Penetrometer
1	Total weight (kg)	1.25
2	Maximum small cone index (kPa, kg)	5600, 75
3	Maximum large cone index (kPa, kg)	2200, 75
4	Resolution (kg)	0.3
5	Maximum insertion depth (mm)	600
6	Interval spacing (mm)	15, 20, 25
7	Memory capacity (no of insertions)	772
8	Small cone size (diameter, mm and area mm^2)	12.83, 130
9	Large cone size (diameter mm and area mm^2)	20.27, 323
10	Shaft size (diameter, mm)	9.53

Fig 5: Soil profile recording with the Field SC 900 Cone Penetrometer

3. Result and Discussion

The cone index recorded with the help of the Field SC 900 cone penetrometer from all four blocks (B1, B2, B3, B4) showed variations at each depth of soil during penetration. The cone index recording at block (B1) for the insertion P1, P2, P3, P4, P5, P6, P7, P8 and P9. The maximum cone index in block (B1) at 175, 350, and 450 mm was 2.7793, 4.72222, and 5.2714 MPa, respectively as shown in Fig. 6. The maximum cone index in block (B2) at 175, 350, and 450 mm was 2.6531, 4.5925, and 5.1408 MPa, respectively as shown in Fig. 7. It was also found that in some cases the penetration stopped many times and could not take readings when encountered with the hard-frying pan area was deep and it was nearly impossible to penetrate the probe into the soil hard fragmentation at a certain depth. Similarly, the maximum cone index in block (B3) at 150, 375, and 450 mm was 2.253, 4.3.5081, and 4.8279 MPa, respectively as shown in Fig. 8. The maximum cone index in block (B4) at 175, 350, and 450 mm was 2.1252, 3.378, and 4.5571 MPa, respectively as shown in Fig. 9. It was observed from the data that the hardpans were found in the deeper layers in all the four blocks which even reached up to 5 MPa. Similar, results were also observed when the mean data from four blocks were plotted in the graph as shown in Fig. 10.

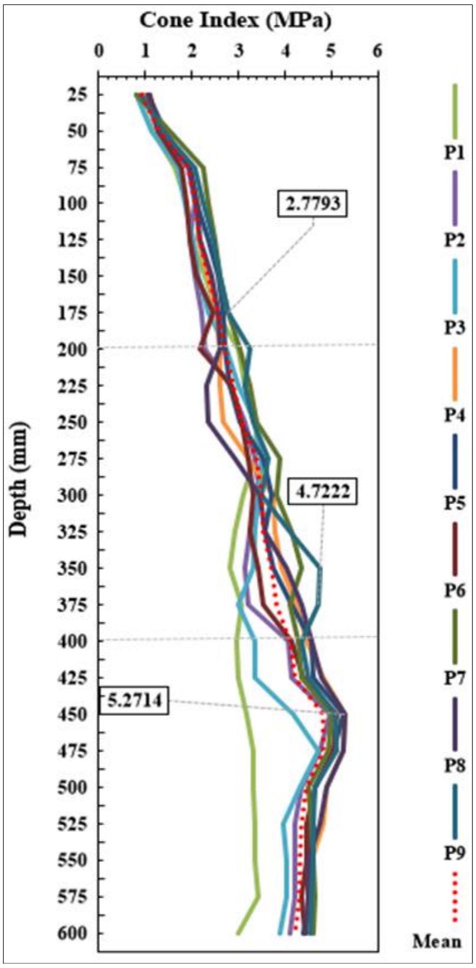

Fig 6: Cone Index readings at Block (B1)

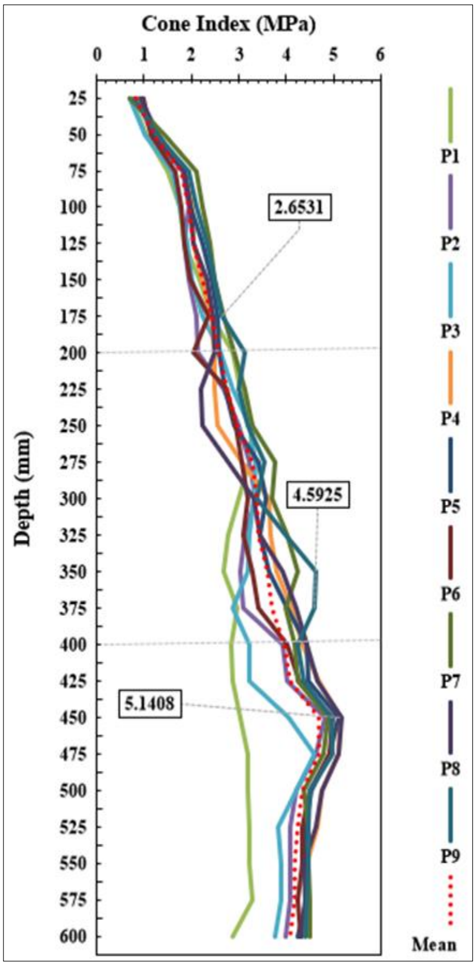

Fig 7: Cone Index readings at Block (B2)

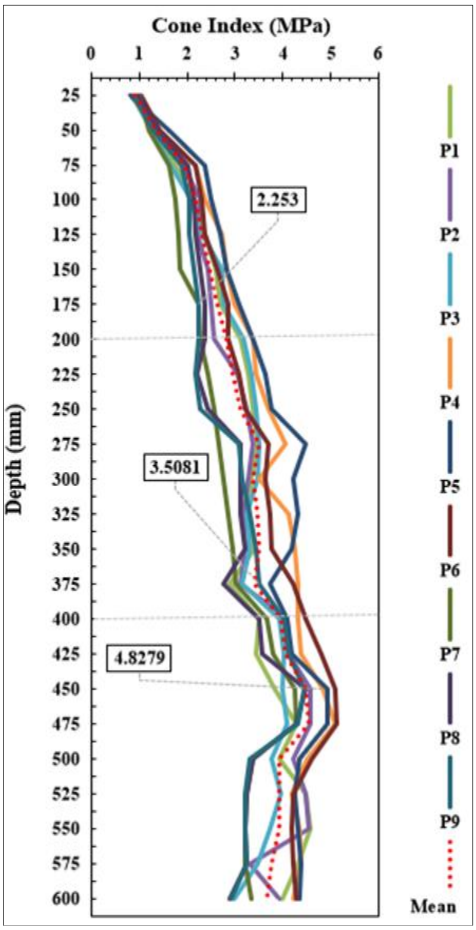

Fig 8: Cone Index readings at Block (B3)

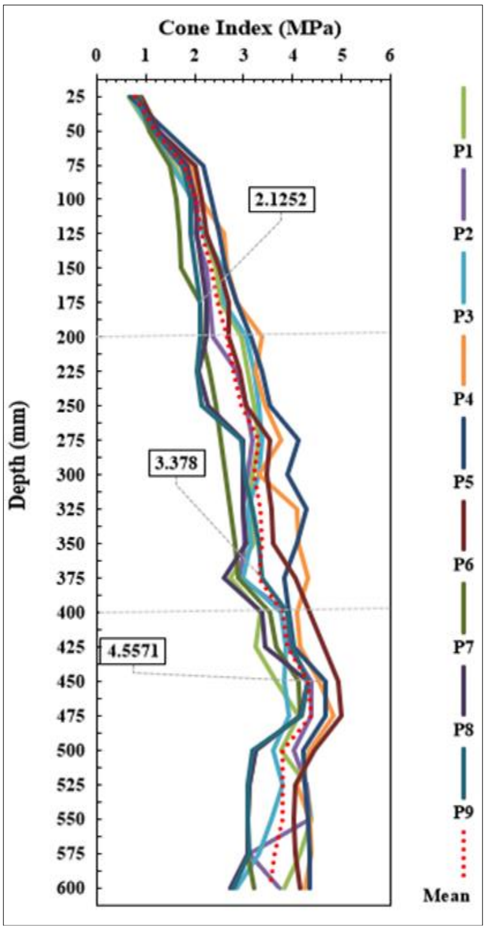

Fig 9: Cone Index readings at Block (B4)

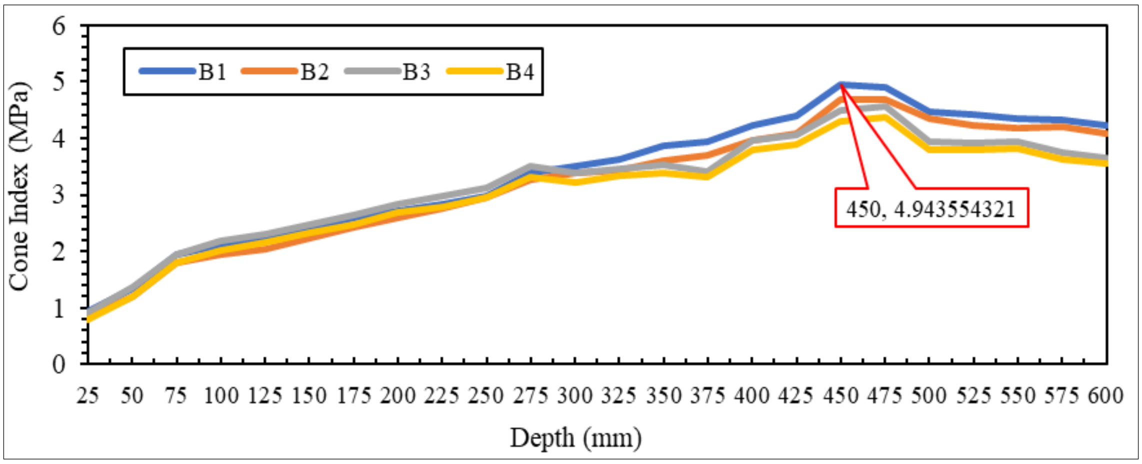

Fig 10: Blocks were plotted in the graph

4. Conclusion

The field experiment was successfully carried out to predict hardpan layers in the soil profile depth-wise. It was also observed from the graphical data that hardpan occurred in all the blocks from 150 mm to 450 mm ranging from 2 to 5 MPa. Similarly, studies should be carried out after a span of time in the agricultural field for proper tillage management to eradicate any harmful effect of hardpans on yield output.

5. References

1. Aubertot JN, Durr C, Richard G, Souty N, Duval Y. Are penetrometer measurements useful in predicting emergence of sugar beet (*Beta vulgaris* L.) seedlings through a crust?. J Plant Soil. 2002;2:177-86.
2. St. Joseph MI. ASAE standards Soil cone penetrometer. ASABE standards: ASAE Standards S313.2. DEC 94. 45th Ed. American society of Agricultural Engineer; c1998. P. 945-55.
3. Alimardani R. Design and construction of a tractor mounted penetrometer. J Agri. Soc. Sci. 2005;4:297-300.
4. Hendrick JG. Recording soil penetrometer. J Agri Engng. Res. 1969;14:183-86.
5. Lowery B, Morrison JE. Soil penetrometers and penetrability. In: Dane JH, Topp GC. Methods of soil analysis. Madison: Soil Science Society of America; c2002. p. 363-88.
6. Sun Y, Ma D, Schulze LP, Schmittmann MR. On-the-go measurement of soil water content and mechanical resistance by a combined horizontal penetrometer. Soil Till Res. 2006;86:209-17.
7. Torres E, Saraiva OF. Soils of mechanical soil impedance in agricultural systems with soybean. Londrina: Embrapa Soja. Circula Technica 23; c1999. p. 1-58.
8. Kumar V, Bector V. Recent Trends in Measurement of Soil Penetration Resistance and Electrical Conductivity of Agricultural Soil and Its Management under Precision Agriculture. AMA-Agric Mech Asia Africa & Latin America. 2022;53:12-20. Doi:10.13140/RG.2.2.15977.57447.