1. Introduction

Agriculture is regarded to be a main reason that transform the soil although agriculture is the essential for mankind to survive and thrive.

Among the soil properties, the physiochemical properties such as pH, EC (Electrical Conductivity) are meaningful to improve crop cultivation and pest control in agriculture\(^1\).

Also, the mechanization for agriculture has been main issue to improve the productivity in the environment which labor is harsh along with the social condition which labor shortage has been...
enlarged since the 1970 in South Korea. Thus, Cone Index (CI), moisture content and soil classification related to the interaction between soil and machinery has been studied.

And then the physical properties such as Cone Index (CI), moisture content, soil classification are meaningful for agricultural machinery such as agricultural tractors and rice transplanters to work on the field. Intrinsically, the field related to soil is so large including soil physics, chemistry and biology that the soil related research is likely to be limited to the specific scope such as soil physics or soil chemistry. However, agriculture is related to interdisciplinary scope.

Status of soil is important for plants including crops including rices to grow well and have nutritive substance. There is a few study which report chemical, physical, and biological attributes of soil. Thus, we decided to characterize the paddy field in Chungbuk National University where rice has been cropped at least for five years as shown in figure 1.

![Fig. 1 Paddy Fields for obtaining data such as pH, Electrical Conductivity (EC), moisture content, Cone Index (CI) and soil classification; (a) map of the site where paddy field is located; (b) paddy field where soil is taken in Chungbuk National University; (c) soil compaction by men; (d) measuring CI; (e) obtaining soil samples at 30 points; (f) drying moisture of the sampled soil in the oven](image)

### 2. Materials and Methods

#### 2.1 EC and pH

Electrical Conductivity (EC) which is the reciprocal of the electrical resistance is high in metals such as silver, copper, gold, aluminum, zinc, nickel, and brass in general. Via soil pH, we can decide the type of plants fit for any field because it can be a rough indicator of the plant availability of nutrients in the soil.

#### 2.2 Cone Index

Cone Index can be obtained using the soil penetrometer as shown in figure 2(a). Cone Index value can be measured by a load cell sensor inside the soil penetrometer while soil depth reading is done by a sonic depth sensor as shown in figure 2(b).

![Fig. 2 Soil penetrometer which can measure Cone Index (CI); (a) picture of Soil penetrometer (SC900, Spectrum Technologies, Inc.); (b) Schematic diagram that elucidate the principle to measure CI (Extracted from User’s Manual of Spectrum Technologies)](image)
2.3 Moisture Content
Moisture content can be obtained by comparing the weight before and after drying in the oven at 105°C for 24 hours. Moisture Content (MC) from 30 soil samples were obtained by

\[ MC = \frac{M_2 - M_3}{M_3 - M_1} \times 100 \]

where,
\[ M_1 = \text{the weight of soil can without soil} \]
\[ M_2 = \text{the weight of soil can with soil} \]
\[ M_3 = \text{the weight of soil can with dried soil} \]

2.4 Soil Classification
Soil was classified using sieve analysis with a sieve shaker as shown in figure 3(c) and 8 kinds of sieves as shown in figure 3(d) through 3(f).

3. Results and Discussion

3.1 EC and pH
EC and pH data were obtained 2 times as shown in table 1.

3.2 Cone Index
Cone Index (CI) data were obtained in 30 sites as shown in table 1 through 10. CI has trend that it is the smallest in topsoil and grows as depth becomes deeper. Cone penetrometer is defined to be a 30° circular stainless steel cone with driving shaft[10]. Also, Cone Index (CI) was defined to be the force required to push the penetrometer through a specified small increment of soil[10]. The CI obtained from 30 sites ranged between 207kPa and 3208kPa and the reason of the variation is likely to be resulted from the difference of the soil compaction degree. The measured CI is shown in table 2 through 11.

Table 1 Electrical Conductivity (EC) and pH of 2 points of sites in the paddy field

| Site No. | EC, us/cm | pH   |
|---------|-----------|------|
| 1       | 48.29     | 7.60 |
| 2       | 47.76     | 7.58 |
| Average | 48.03     | 7.59 |

Table 2 CI measured at sites 1, 2, and 3

| Site No. | Site 1 | Site 2 | Site 3 |
|----------|--------|--------|--------|
| Point, cm| CI, kPa| CI, kPa| CI, kPa|
| 5        | 1138   | 931    | 379    |
| 10       | 1345   | 1483   | 1345   |
| 15       | 1449   | 1690   | 1483   |
| 20       | 1449   | 1414   | 1621   |
| 25       | 1932   | 1104   | 2001   |
### Table 3 CI measured at sites 4, 5, and 6

| Site No. | Site 4 CI, kPa | Site 5 CI, kPa | Site 6 CI, kPa |
|----------|---------------|---------------|---------------|
| 5        | 931           | 207           | 1345          |
| 10       | 1621          | 1794          | 2242          |
| 15       | 1414          | 2277          | 2208          |
| 20       | 1242          | 1828          | 2173          |
| 25       | 1483          | 1656          | 2587          |

### Table 4 CI measured at sites 7, 8, and 9

| Site No. | Site 7 CI, kPa | Site 8 CI, kPa | Site 9 CI, kPa |
|----------|---------------|---------------|---------------|
| 5        | 1932          | 862           | 931           |
| 10       | 2173          | 1207          | 759           |
| 15       | 2035          | 1656          | 966           |
| 20       | 2139          | 1311          | 897           |
| 25       | 2553          | 1242          | 862           |

### Table 5 CI measured at sites 10, 11, and 12

| Site No. | Site 10 CI, kPa | Site 11 CI, kPa | Site 12 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 621            | 690            | 724           |
| 10       | 1621           | 1414           | 1690          |
| 15       | 1207           | 1345           | 1828          |
| 20       | 1138           | 1345           | 1173          |
| 25       | 1242           | 1863           | 655           |

### Table 6 CI measured at sites 13, 14, and 15

| Site No. | Site 13 CI, kPa | Site 14 CI, kPa | Site 15 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 621            | 586            | 345           |
| 10       | 1069           | 1828           | 862           |
| 15       | 1000           | 1897           | 1725          |
| 20       | 1345           | 1794           | 1621          |
| 25       | 1725           | 1414           | 1587          |

### Table 7 CI measured at sites 16, 17, and 18

| Site No. | Site 16 CI, kPa | Site 17 CI, kPa | Site 18 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 724            | 931            | 690           |
| 10       | 966            | 379            | 1173          |
| 15       | 1276           | 1587           | 931           |
| 20       | 1759           | 1380           | 1311          |
| 25       | 1656           | 1414           | 1242          |

### Table 8 CI measured at sites 19, 20, and 21

| Site No. | Site 19 CI, kPa | Site 20 CI, kPa | Site 21 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 1000           | 1380           | 1449          |
| 10       | 793            | 897            | 483           |
| 15       | 1138           | 1104           | 1207          |
| 20       | 1207           | 1173           | 1207          |
| 25       | 1276           | 3208           | 1311          |

### Table 9 CI measured at sites 22, 23, and 24

| Site No. | Site 22 CI, kPa | Site 23 CI, kPa | Site 24 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 1138           | 931            | 1621          |
| 10       | 2311           | 1276           | 1242          |
| 15       | 1966           | 1587           | 1483          |
| 20       | 2070           | 1725           | 1621          |
| 25       | 2725           | 2484           | 2484          |

### Table 10 CI measured at sites 25, 26, and 27

| Site No. | Site 25 CI, kPa | Site 26 CI, kPa | Site 27 CI, kPa |
|----------|----------------|----------------|---------------|
| 5        | 655            | 793            | 931           |
| 10       | 1587           | 1483           | 1932          |
| 15       | 1483           | 1828           | 1656          |
| 20       | 1656           | 1483           | 1069          |
| 25       | 1345           | 2656           | 2035          |
Table 11 CI measured at sites 28, 29, and 30

| Site No. | CI, kPa | CI, kPa | CI, kPa |
|----------|---------|---------|---------|
| 5        | 241     | 1069    | 1621    |
| 10       | 621     | 759     | 1069    |
| 15       | 690     | 1242    | 862     |
| 20       | 1138    | 1414    | 69      |
| 25       | 1414    | 2932    | 1725    |

Table 12 moisture content at sites 1 through 30

| Site No. | M.C. % | Site No. | M.C. % |
|----------|--------|----------|--------|
| 1        | 17.3   | 16       | 11.1   |
| 2        | 21.9   | 17       | 19.8   |
| 3        | 15.8   | 18       | 12.6   |
| 4        | 15.0   | 19       | 19.5   |
| 5        | 19.4   | 20       | 23     |
| 6        | 13.9   | 21       | 18.5   |
| 7        | 11.8   | 22       | 21.7   |
| 8        | 16.6   | 23       | 21.0   |
| 9        | 13.0   | 24       | 22.6   |
| 10       | 16.0   | 25       | 16.6   |
| 11       | 19.5   | 26       | 19.5   |
| 12       | 14.3   | 27       | 18.3   |
| 13       | 11.2   | 28       | 17.6   |
| 14       | 11.5   | 29       | 23.4   |
| 15       | 13.9   | 30       | 16.6   |

3.3 Moisture Content

Moisture content in the soil taken from site 1 through 30 is shown in table 12.

3.4 Soil Classification

Among 30 soil samples, one soil sample was spilled from the soil sieve while sieving. Also, the data was not reasonable for one soil sample because the weight after removing one of the sieve was below zero. Thus, the number of final soil samples used for soil classification was not 30 but 28. Soil was classified according to USDA criterion as shown in figure 4. The percentages of gravel, sand, and clay were each 13.4%, 56.5%, and 30.1%.

![Soil distribution](image)

The passing ratio was similar among soil sampled on the 28 spots. In average, the ratio of the gravel was 13.4%, sand 56.5%, clay 30.1%. Thus, the soil can be classified into the loam soil because the ratio of clay is between 25% and 37.5% (USDA criterion).

4. Conclusion

We obtained the data in terms of soil chemistry and soil mechanics synthetically from the soil of 30 sites in Chungbuk National University. Details of this study are as below
1. The Cone Index and Moisture Content was obtained for 30 soil samples and soil was classified into loam after sieving the 28 soil samples of the field where rice has been cropped for recent 5 years.
2. The Cone Index and Moisture Content was obtained for 30 soil samples and soil was classified into loam after sieving the 28 soil samples of the field where rice has been cropped for recent 5 years.
3. The soil data related to soil chemistry and soil mechanics was obtained synthetically so that it can be used as basic information to improve cultivation, pest control and machine interaction.
4. It is expected that we can get the relationship between the soil chemistry and mechanics data on the field after growing specific grain.
후 기

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