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On-field soil properties for soya bean crop

V. V. Navarkhele

Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, (MS) India

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ABSTRACT

A field experiment was conducted to investigate the effect of soil properties on soya bean crop. The study has been carried out to determine the effect of soil physical- chemical properties on soya bean crop in the low precipitation area. The soil water content, resistivity, conductivity, P^H and total dissolved solids were measured on the experimental field. The texture, gravimetric water content, volumetric water content, soil melting capacity, bulk density, porosity, water holding capacity and chemical compositions of the soil's from the same fields were determined in laboratory. The profile probe (PR2) soil moisture measurement system was used to determine the soil water content and a two probe resistance meter was used to measure soil resistivity. The texture analysis of the soil samples was accomplished with mechanical sieves. The results show that the soil water content and resistivity required for the soya bean crop to grow and give good yield should be in the range of 26 to 43 percent cm^3cm^{-3} and 177 to 340 K- Ohm-cm respectively. The P^H should be neutral to slightly basic and conductivity should be non saline. The results also show that soya bean crop will grow in clayey as well as sandy loam soils.

Keywords: Profile probe; Resistance meter; Low precipitation area; soil properties; Soya bean covered experimental field.

INTRODUCTION

There are lots of development in the agricultural such as equipments, knowledge, and number of things that affect crop productivity. Farmers involved in precision agriculture can now get more detailed information about their farming options than ever before. In addition to yield boundary and filed attribute maps, new electronic, mechanical and chemical sensors have been developed to study soil and plant properties [1, 2].

The real part of complex dielectric constant is an important parameter through which soil water content can be determined. The knowledge of the behavior of soil water is useful since it affects intensively many physical and chemical reactions of the soil as well as plant growth. The soil water content plays an important role in many agronomic, ecological and hydrological investigations to understand the soils chemical, mechanical, hydrological and biological relationships. The theoretical basis for soil moisture measurement is based on large contrast between dielectric constant of water (80) and that of dry soil (3 to 5) [3-5]. The dependence of dielectric constant on moisture can be measured with time domain reflectometry (TDR), frequency domain reflectometry (FDR) or number of sensors available in the market [6-9].

The soil water content is most important physical property of the soil which is used to characterize the availability of water for plants. Large range of approaches is available to measure this. The aim of these methods is either to provide fast measurement value or to provide value for continuous measurements over large periods. All approaches need calibrations for individual soil if absolute values are actually needed and they can have a restricted linearity at high or low moisture ranges. Most alternative methods describe the physical properties of a very restricted solid volume, which then becomes the representative for a large bulk volume. Several reviews of soil water content measurement have been published in the past, notably those by [10]. More recently, another review has been published by [11, 12] has provided very useful summaries of theory and practice of many of the techniques available, and the contribution of the Gardener has been revised and updated [13, 14].

In present study the author has reported proper soil properties for soya bean crop. The measurements were carried out on two agronomy farm covered with soya bean which was around 0.5 ha. Prior to the measurements plots have been made on these soya bean fields. The south zone of Marathwada is a vast semi-arid area with an average annual precipitation ranging from 300 to 450 mm and more than 80 % of the cropland from this area receives no irrigation. The main crops are Bajra, Jawar, Pulses, Mustard, Black gram, Green gram, Sesame, Groundnuts and soya bean which are periodically rotated. This rotation is necessary for food security in this region. From long time manure application to the soil was the main practice. Now a day this practice has been changed, farmers are adding chemical fertilizers along with manure to increase the crop productivity. So, a field experiment was set up on this farm in 2012 to study the effect of change in water and fertilizer application practices on soil properties on soya bean crop. The soya bean crop on the experimental field is shown in Figure 1.

EXPERIMENTAL SECTION

2.1 Field location

The field experiment was conducted on an agronomy farm (18^0 24′ N, 76^0 36′ E and 631 m altitude) at Ramling Mudgad, District- Latur of Maharashtra- India. The color of the soils was faint black and dark black. Under average climate conditions, the area is an arid and receives 300 mm to 350 mm average precipitation that occurs in the month of July through October. March through May is the driest period for crop growth. Little precipitation occurs during the winter months of October and November. The mean annual temperature is around 28 ^{0}C. The mean annual sunshine period is around 8520 h.

2.2 Soil sampling

Soil samples were collected from 10 to 15 cm depth layer at different points on the experimental site. Around 10 to 12 soil samples were taken from each site and after removing the surface organic materials and fine roots all the samples mixed thoroughly to make one composite sample. The soil samples were then brought to laboratory in rigid containers to avoid atmospheric changes and breaking the soil aggregates. After air drying for a week, the soil sample was divided into two groups for analysis. Prior to the analysis, each soil sample was passed through a 5 mm sieve.

2.3 Soil Characterization

Soil P^H was measured in distilled water at soil: water ratio of 1:5 using a P^H meter after shaking the suspension for 30 min and equilibration for 30 min. The same suspension was used to determine the electrical conductivity (EC) after allowing them to settle for half an hour using an EC meter. Particle size distribution (soil texture) was determined using mechanical sieves. Available soil organic matter (SOM), Nitrate (N), Phosphate (P_20_5), Ammoniacal Nitrate (N), and Potassium (K) were determined in laboratory. The on field soil P^H and electrical conductivity (EC) was measured with the help of hand held P^H and conductivity meters.

2.4 Soil water content

A profile probe (PR2) soil moisture measurement system was used to measure the soil water content. It is based on the principle of frequency domain reflectometry (FDR) technique. Using this probe the soil water content can be measured on agronomic farm up to one meter depth as 100 mm, 200 mm, 300 mm, 400 mm, 600 mm and 1000 mm. It works by inserting the probe into the soil. When power is applied to the probe, it creates a 100 MHz frequency signal that is applied to the stainless steel rings, which transmit an electromagnetic field extending about 1000 mm into the soil. The field passes easily through the access tube wall, but less easily through the air gaps. The water content in the soil surrounding the rings dominates its permittivity. The permittivity of soil has strong influence on the applied field, resulting in stable voltage output that acts as a simple sensitive measure of soil water content.

The water content was measured on the experimental site in the month of September, when soya bean crop was two months old. Prior to the measurements plots have been made on the test locations. The water content was measured at the crop root (i.e. at 15 cm depth) with equal intervals. The measured soil water content at the experimental location one and two is given in Table 1 and 2 respectively**.** The accuracy of measurement is in between ± 0.06 cm^3cm^{-3} with generalized soil. Figure 2 and 3 shows the photograph while measuring soil water content at location one and two respectively.

2.5 Soil Resistivity

Knowledge of soil resistivity is the key factor to decide structural stability. It varies widely from field to field and changes seasonally. It depends on water content, chemical composition, soil type (sand, clay and silt), and temperature. It has a direct impact on the degree of corrosion in underground pipelines. The decrease in soil resistivity relates to an increase in rusting corrosion activity of the soil therefore the protective treatment is necessary. Soil resistivity data is also useful to make sub-surface geophysical survey. It affects the design of a grounding system. When it is possible to choose the location of the earth connection, resistivity measurement helps to qualify the soil [15-20].

To study the corrosion activity of the soil at the experimental site the resistivity was measured at the depth of 10 cm. The resistance meter works by inserting the two probes into the soil. The probes are made from copper rods and are purchased from the local market. It is tapered at one end and wired at another end. The probes are very sensitive for water content changes. The probes established an electrical contact with the earth. The meter injects constant current through the ground via. the two probes. The current flowing through the earth develops a potential difference. Measuring V and I, the resistance per cm was calculated. The resistivity was determined using the following formula given by Wenner [21].

$$\rho = 2\Pi AR \qquad (1)$$

Where ρ, A and R are the soil resistivity in Ohm- cm, horizontal spacing between the probes and the resistance measured form the meter respectively. The measured soil resistivity at the test location one and two is given in Table 2 and 4 respectively.

2.6 Soil conductivity

Soil conductivity is one of the simplest, least expensive soil measurements available to the farmers today. Conductivity refers to the electrical conductivity (EC) of a solution, or it is a measure of the electric current generated by charged ions in the solution. The electrical conductivity varies not only to the concentration of salts present, but also to the chemical composition of the nutrient solution and soil moisture. It does not differentiate among the various elements, it measures total solutes. Plants tend to take nutrients up in an ionic form, so soil conductivity of a soil solution give an idea of the nutrient content in a soil. Measurement of electrical conductivity is nothing but monitoring the changes in the nutrient solution over time [22, 25]. That will give an idea of what type of adjustments should be made to keep the solution in balance for the crop to grow and give maximum yield. The conductivity at the test locations one and two was measured with the help of hand held conductivity meter at the crop root which is given in Table 1 and 2 respectively. From the knowledge of conductivity the total dissolved solids (TDS) was determined which is illustrated in the same Table 1 and 2.

2.7 Soil P^H

The P^H of a soil is the hydrogen ion activity. It is very important because soil solution carries it nutrients such as Potassium (K), Phosphorus (P) and Nitrogen (N) that plants need in specific amounts to grow and fight off diseases. Therefore soil P^H measurement is very essential for healthy crop. All fertilizer, fungicide and water can't save a yard which is out of soil P^H balance. Without starting with the proper soil P^H, all effort and energies will be waste. Only when the Soil P^H is right then the other variables become significant. When soil pH is in balance, plants and other forms of life have a chance to prosper and live healthy happy lives. When soil P^H is not proper, growth will slow. Plants will not be able to utilize nitrogen and other food properly. The soil P^H at the test location one and two was measured with the help of hand held pH meter at the crop root which is given in Table 1 and 2 respectively.

RESULTS AND DISCUSSION

The soil properties at the experimental test location one and two is illustrated in Table 1 and 2 respectively. The soil texture, physical and chemical properties of the soil samples are illustrated in Table 3, 4 and 5 respectively.

The soil water content was measured at 30 cm deep from the soil surface. The sensor of the probe was at 15 cm i.e. at the crop root. The soil water content was different at different locations and it is in the range of 26.20 % to 37.80 % ($cm^3cm^{-3)}$ on field one and 26.00 % to 41.50% ($cm^3cm^{-3)}$ on field two. The variation in water content is more on filed two than that of field one. This may be due to the variation in physical properties at the fields.

The soil resistivity was measured on the same fields with the help of a resistance meter. The resistivity was different at different locations and it was found in the range of 198 to 306 K- Ohm-cm on field one and 191 to 304 K- Ohm-cm on field two. The variation in resistivity may be the dissimilar proportion of water content, physical and chemical composition at the test locations. The resistivity is higher on the test locations because it was measured at the soil surface that is at 10 cm depth and also due to more horizontal space between the two probes (100 cm). The results are in agreement with the earlier work of the authors [26, 27].

The soil PH was found in the range of 7.4 - 7.9 on test location one and 6.9 - 7.2 on location two. The ionic conductivity was in the range of 270 - 295 μ℧/cm on test location one and 560 - 582 μ℧/cm on location two. From the knowledge of conductivity the total dissolved solids (TDS/ppm) was determined and it was found in the range of 135 to 162 ppm for test location one and 280 to 320 ppm for location two.

The soil texture was determined in laboratory after air drying the soil samples. Amongst the two soils, the soil sample from test location two has higher percentage of clay and lower percentage of course sand. Therefore the soil on field two has higher percent of water holing capacity than that of field one.

The soil chemical analysis shows, the available organic carbon is low and Nitrate Nitrogen (N) is high at both fields. The available Potassium (K) is medium at field one and very high at field two. Similarly, the available Phosphate (P_2O_5) is low at field one and high at field two. The P^H is slightly basic and conductivity is non saline at both the test fields.

Table 1. On field measurements for soya bean crop at test location one

	Volumetric water content measurement			Resistivity measurement			Conductivity, TDS and P^H measurements		
Sr.No	Test location	Depth of the profile probe in cm	Percentage volumetric water content ($cm^3cm^{-3)}$	Spacing between the probes (A) in cm (Horizontal)	Depth of the probes (B) in cm (Vertical) in cm	Soil resistivity (ρ) (K Ohm - cm)	On field ionic Conductivity (EC) (μ℧/cm)	Total dissolved solids (ppm)	On field P^H
	A								
0		30	37.80						
1		30	30.10	0 - 100	10	261.08	290	145-159	7.7
2		30	26.20	100-200	10	306.50	280	140-154	7.8
3		30	28.45	200-300	10	282.98	288	144-158	7.6
4		30	27.52	300-400	10	286.24	294	147-161	7.9
5		30	28.80	400-500	10	279.56	284	142-156	7.6
	B								
0		30	28.80						
1		30	29.11	0 - 100	10	271.28	270	135-148	7.4
2		30	28.20	100-200	10	289.56	282	141-155	7.5
3		30	27.42	200-300	10	284.24	291	145 -160	7.6
	C								
0		30	27.42						
1		30	33.41	0 - 100	10	240.40	281	140-154	7.5
2		30	35.86	100-200	10	207.64	285	142-156	7.6
3		30	36.02	200-300	10	199.21	295	147-162	7.8
4		30	35.66	300-400	10	219.78	285	142-156	7.6
5		30	28.16	400-500	10	275.21	282	141- 155	7.5
	D								
0		30	34.16						
1		30	33.23	0 - 100	10	224.54	273	136-150	7.4
2		30	37.34	100-200	10	208.57	283	141-155	7.5
		30	37.80	200-300	10	198.61	292	146-160	7.6

Table 2. On field measurements for soya bean crop at test location two

	Volumetric water content measurement			Resistivity measurement			Conductivity, TDS and P^H measurements		
Sr.No	Test location	Depth of the profile probe in cm	Percentage volumetric water content (cm^3cm^{-3})	Spacing between the probes (A) in cm (Horizontal)	Depth of the probes (B) in cm (Vertical) in cm	Soil resistivity (ρ) (K Ohm - cm)	On field ionic Conductivity (EC) (μ℧ /cm)	Total dissolved solids (ppm)	On field P^H
	A								
0		30	33.10						
1		30	30.10	0 - 100	10	253.42	573	286-315	7.0
2		30	29.20	100-200	10	268.42	574	287-315	7.1
3		30	27.40	200-300	10	293.58	580	290-319	7.2
4		30	26.00	300-400	10	304.16	568	284-312	6.9
5		30	26.90	400-500	10	300.98	565	282-310	6.9
	B								
0		30	26.90						
1		30	31.21	0 - 100	10	249.42	572	286-314	7.0
2		30	35.54	100-200	10	223.42	574	287-315	7.0
3		30	39.40	200-300	10	208.74	560	280-308	6.9
	C								
0		30	39.40						
1		30	42.20	0 - 100	10	191.08	566	283-311	6.9
2		30	34.27	100-200	10	216.08	565	282-310	6.9
3		30	41.50	200-300	10	193.42	573	286-315	7.0
4		30	41.13	300-400	10	177.48	582	291-320	7.1
5		30	37.89	400-500	10	207.42	575	287-316	7.1
	D								
0		30	37.89						
1		30	38.44	0 - 100	10	196.58	579	289-318.	7.1
2		30	30.29	100-200	10	259.58	580	290-319	7.2
3		30	32.71	200-300	10	243.42	575	287-316	7.0

Table 3. Soil texture

Sr. No.	Soil texture	Soya bean field one	Soya bean field two
1	Coarse Sand (Percentage)	27.56	6.07
2	Fine sand (Percentage)	9.93	7.56
3	Silt (Percentage)	26.24	39.21
4	Clay (Percentage)	36.27	47.16

Table 4. Soil physical properties

Sr. No.	Physical properties	Soya bean field one	Soya bean field two
1	Gravimetric water content (θg)	0.11 $g.g^{-1}$	0.12 $g.g^{-1}$
2	Volumetric water content(θv)	0.14 $cm.cm^{-3}$	0.15 $cm.cm^{-3}$
3	Soil melting capacity	0.350 %	0.460 %
4	Water holding capacity	32.00 %	42.83 %
5	Bulk density	1.29 g/cm^3	1.26 g/cm^3
6	Soil porosity	0.51	0.52

Table 5. Soil chemical properties

Sr. No.	Chemical Composition	Soya bean field one	Remark	Soya bean field two	Remark
1	Organic carbon (% by wt)	Below 0.5%	Low	Below 0.5 %	Low
2	Nitrate (Kg/hectare as N)	20.41	High	20.41	High
3	Available phosphate (Kg/ hectare as P_2O_5)	0	Low	Above 29.48	High
4	Available potassium (Kg/hectare as K)	45.36 - 113.40	Medium	158.76	Very high
5	Ammoniacal Nitrogen(Kg/hectare as N)	29.48	Medium	5.89	Low
6	Conductivity	220 μ℧ /cm	Non-saline	1340 μ℧ /cm	Non-saline
7	Total dissolved solids (TDS)	121-165 ppm	less	670-1005 ppm	Medium
8	pH	7.9	Slightly basic	7.7	Slightly basic

Figure 2. On field soil water content measurements with the help of profile probe at plot one.

Figure 3. On field soil water content measurements with the help of profile probe at plot two.

Figure 4. On field soil resistivity measurements with the help of profile probe at plot one.

Figure 5. On field soil resistivity measurements with the help of profile probe at plot two

CONCLUSION

The experimental measurements presented in this paper leads to the following major conclusions:
i) The on field soil water content should be in the range of 26 % to 42 % ($cm^3cm^{-3)}$.
ii) The on field soil resistivity should be in the range of 191 to 306 K- Ohm-cm.
iii) The soil P^H should be around neutral to slightly basic.
iv) The conductivity should be around 270 – 582 µ℧ /cm.
v) The soya bean crop will grow in clayey as well as in sandy loam soils.

vi)The soya bean crop will grow in the soils having less organic carbon.
vii) The said crop will grow in soils having high Nitrogen (N).
viii) The said crop will grow with or without phosphate (P) and potassium (K) required should be medium to very high.

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