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Soil chemical properties of soybean [*Glycine max* (L.) Merill] growing soils in Dharwad Taluk (Karnataka)

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Abstract
A study was undertaken to assess the chemical properties of soybean growing soils of Dharwad taluk in Dharwad district, Karnataka. Seventeen representative villages were chosen and total fifty one surface soil samples (0-15 cm) collected and analysed for chemical properties of soybean growing soils. Based on the average grain yields in 51 fields, the entire group was divided into below average and above average yield categories. Mean yield of selected fields was 14.67 q ha^{-1}. Results revealed that the soil pH (1:2.5) varied from 6.81 to 8.67 with an average of 7.83 and 7.02 to 8.13 with an average of 7.68 in below and above average yield category respectively. Electrical conductivity (1:2.5) of soils varied from 0.13 to 0.45 with an average of 0.21 and 0.10 to 0.32 with an average of 0.20 in below and above average yield category respectively. The organic carbon content varied from 3.6 to 4.9 g kg^{-1} with an average of 4.27 g kg^{-1} and 4.6 to 7.5 g kg^{-1} with an average of 5.88 g kg^{-1} in below and above average yield category respectively. The data on free $CaCO_3$ content varied from 52 to 152 g kg^{-1} with an average of 89.22 g kg^{-1} and 55 to 112 g kg^{-1} with an average of 74.53 g kg^{-1} in below and above average yield category respectively. Among the chemical properties, soil organic carbon was found to be positive and significantly correlated with yield (0.599**) in both below and above average yield categories.

Keywords: pH, EC, Organic Carbon, $CaCO_3$, Soybean

Introduction
Soybean [*Glycine max* (L.) Merill], is an important oilseed crop having world wide adaptation, being the "Golden Bean", of the 20th century is a species of legume, native to East Asia, widely grown for its edible bean which has numerous uses. Soybean is one of the nature's most versatile and fascinating crop in the present farming system of Indian agriculture. It is now the largest oilseed crops in India after groundnut. The grain legume is considered as a wonder crop due to its dual qualities *viz.*, high protein (40 %) and oil content (20 %). Soybean being rich source of amino acids, unsaturated fatty acids, vitamins and minerals, it is being widely used in different forms and acquires special importance in diet of Indian and other Asian countries as a substitute to relieve from hunger and malnutrition. In addition to this, its protein has five per cent lysine, which is deficient in most of the cereals and enriching the cereal flour with soybean improves the nutritive quality. Being an easy care crop, it is widely acceptable by majority of farmers and it gets its preference for all type of soils (Jagdish and Hajare, 1992) [5].

Soybean was introduced in India during 1960's and is gaining rapid recognition as a highly desirable legume and oil seed crop. The main producers of soybean are the United States (36 per cent), Brazil (36 per cent), Argentina (18 per cent), China (5 per cent) and India (4 per cent). India stands next only to China in the Asia - Pacific region. In world, it is grown in an area of 118.01 million hectare with production of 315.06 million tonnes and productivity of 2.67 t ha^{-1} (Anon, 2015) [1]. In India it is grown over an area of 10.02 million hectare with production of 11.64 million tonnes and productivity of 1,062 kg ha^{-1} (Anon, 2015) [1].

Its cultivation has become popular in northern parts of Karnataka due to establishment of processing units and high remunerative prices. The crop has very high yielding potential but its productivity in India (1,062 kg ha^{-1}) and Karnataka (868 kg ha^{-1}) is comparatively low compared to rest of the world (2.67 t ha^{-1}) (Anon., 2015) [1].

Since soil pH affects the availability of most essential plant nutrients and is a controlling factor for many plant and microorganism processes, exposing subsoil with an acidic pH could negatively affect subsequent crop growth. If the soil pH decreases to around 5.5 or less, aluminum toxicity may result (Tisdale *et al*., 1993) [13]. In contrast, molybdenum, required by nodule forming bacteria in soybean that perform N_2 fixation, may become deficient at pH <5.8 (Univ. Ark., 2000) [15]. However, increases in soil pH have been related to increased severity of sudden death syndrome and increased quantities of inocula that cause this disease in soybean (Sanogo and Yang, 2001) [10]. Soybean root growth has also been shown to be sensitive to pH (Suthipradit and Alva, 1986) [12]. Soil organic carbon is considered to be one of the most important pools of soil organic matter. Amount and nature of SOC play a key role in soil quality. Although organic carbon is not a plant nutrient, its low concentrations (0.5-1 % by weight) can have deleterious effect on crop productivity. The depletion of SOC reserves has been cited as a serious threat to the maintenance of soil quality.

Material and Methods

Location of the study area

The study area is Dharwad taluk in Dharwad district, Karnataka. The study area lies between 15^0 21' to 15^0 31' N latitude and 74^0 48' to 75^0 9' E longitude. The location of study the area is presented in Figure 1**.** The study area is situated in Northern Transitional Zone (Zone-8) of North Karnataka. The location of soil samples in selected villages of Dharwad taluk are presented in Figure 2. The area receives a mean annual rainfall of 716.2 mm.

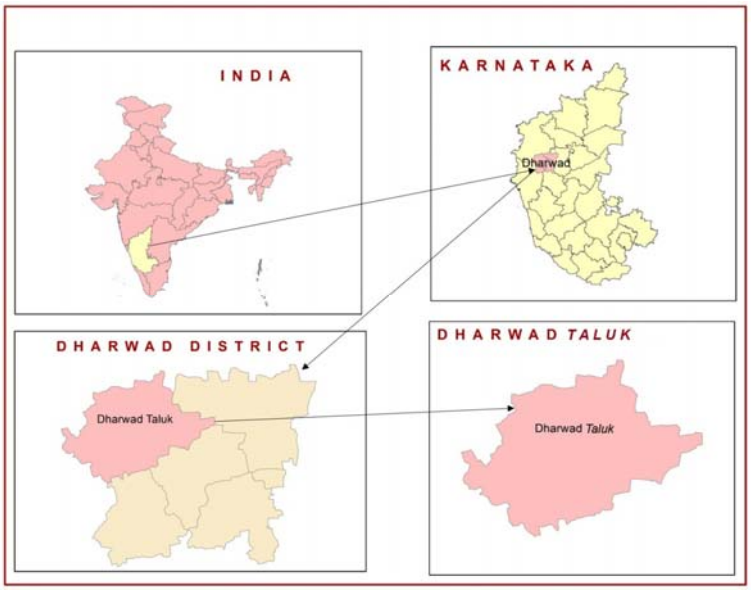

Fig 1: Location of study area

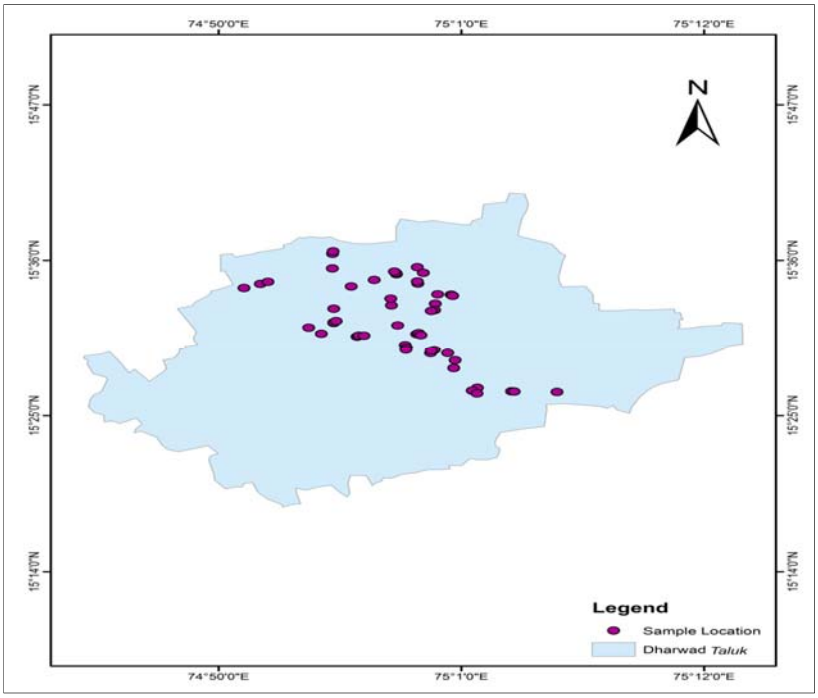

Fig 2: Location of soil samples in Dharwad taluk

Collection of soil samples

In order to study the chemical properties in soils of Dharwad taluk, fifty one surface soil samples (0-15 cm depth) were collected during 2015-16 *kharif* season. The sample location was recorded by using GPS.

Collection of yield data

Crop cutting experiment from the selected farmers fields were carried out. In each of the fields at the time of harvest in area of 3 × 3 m was selected randomly at three different spots. Plants were uprooted in the selected area and pods were separated from plants, yields were recorded by taking average from all the three spots and expressed in quintals per hectare.

Methodology

Soil reaction in 1:2.5 soil-water suspension, electrical conductivity in the supernatant solution of 1:2.5 soil-water suspension determined by pH meter and EC meter, respectively (Sparks, 1996) [11]. The organic carbon content was determined by Walkley and Black's wet oxidation method as described by Sparks (1996) [11]. The free calcium carbonate ($CaCO_3$) was determined by rapid acid titration method as described by Piper (2002) [8].

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Chemical properties

Soil pH

Soil pH in the below average yield category ranged from 6.81 to 8.67 with a mean of 7.83 and standard deviation of 0.566 (Table 1). In the above average yield category, the soil pH ranged between 7.02 to 8.13. The mean and standard deviation were 7.68 and 0.355 (Table 1), respectively. This may be due to their high base status of this soils. Similar observations were made by Nadaf *et al*. (2015) [7] for Tadakod micro watershed of Dharwad.

Electrical Conductivity

The Electrical conductivity of the soil in the below average yield category ranged from 0.13 to 0.45 dS m^{-1} with a mean of 0.21 dS m^{-1} and standard deviation of 0.078 (Table 1). The EC value in above average yield category ranged between 0.10 and 0.32 dS m^{-1}. The mean EC value was 0.20 dS m^{-1} and standard deviation was 0.055 (Table 1). The low EC values were observed in these soils may be due to leaching of salts from surface layer soils. These results were in confirmation with the findings of Tumbal and Patil (2015) [14] who observed non saline nature of the soils due to leaching in Balapur micro watershed of Koppal district.

Organic Carbon

The soil organic carbon content in all the soil samples in below average yield category was low. It ranged from 3.6 to 4.9 g kg^{-1} with a mean value of 4.27 g kg^{-1} and standard deviation of 0.418 (Table 1). In the above average yield category the organic carbon content ranged from 4.6 to 7.5 g kg^{-1} with a mean value of 5.88 g kg^{-1} and standard deviation of 0.709 (Table 1). Organic carbon content of the soils depends mainly on management practices followed by the formers particularly amount of organic manures applied by the farmers. It is also might be due to the quantity of organic manures added more in above average yield category than in below average yield category fields. Similar observations were reported by Karthikeyan *et al*. (2014) [6] in soybean growing soils of Malwa Plateau. Sadhineni *et al.* (2010) [9] also reported that low organic carbon content in some of the soils of Kundgol and Hubli *taluks* of Dharwad district might due to low addition of organic manures.

Free $CaCO_3$

The free $CaCO_3$ indicates that these soils were calcareous in nature. Calcium carbonate content in the below average yield category ranged from 52 to 152 g kg^{-1} with a mean value of 89.22 g kg^{-1} and standard deviation of 32.186 (Table 1). In the above average yield category the calcium carbonate content ranged from 55 to 112 g kg^{-1} with a mean value of 74.53 g kg^{-1} and standard deviation of 16.695 (Table 1). Soil calcareousness might be due to low rainfall and high temperature which favour the accumulation of insoluble carbonates and bicarbonates of calcium in the soil. Binita *et al.* (2009) [4] reported that soil calcareousness in Ghatprabha left bank canal command area of north Karnataka could be due to low availability of water for leaching of carbonates and bicarbonates. Similar observations were also reported by Karthikeyan *et al*. (2014) [6] in soybean growing soils of Malwa Plateau.

Correlation studies

Correlation between soil chemical properties and soybean grain yield

The relationship between different soil chemical properties with soybean grain yield is presented in Table 2.

Among the chemical properties, soil organic carbon was found to be positive and significantly correlated with yield (0.599**) in both below and above average yield categories. The presence of organic matter in higher quantities improves the physical environment of soil which is conducive for better root development and subsequent uptake of nutrients resulting in increased yields of soybean. These results are in accordance with the findings of Bidari (2000) [3] and Anthony *et al.* (2012) [2].

Table 1: Soil chemical properties of soybean growing soils of Dharwad taluk

	Soil pH (1:2.5)	EC (1:2.5) (dS m^{-1})	Organic Carbon (g kg^{-1})	Free $CaCO_3$ (g kg^{-1})
Below average yield category				
Minimum	6.81	0.13	3.6	52
Maximum	8.67	0.45	4.9	152
Mean	7.83	0.21	4.27	89.22
Standard deviation	0.566	0.078	0.418	31.757
Above average yield category				
Minimum	7.02	0.10	4.6	55
Maximum	8.13	0.32	7.5	112
Mean	7.68	0.20	5.88	74.53
Standard deviation	0.355	0.055	0.709	16.695

Table 2: Correlation coefficients between soil chemical properties with soybean grain yield (q ha^{-1})

	Yield	pH	EC	OC	$CaCO_3$
Yield	1				
pH	-0.043	1			
EC	0.077	0.303*	1		
OC	0.599**	-0.146	-0.109	1	
$CaCO_3$	-0.070	0.908**	0.425**	-0.226	1

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

Conclusions

Results revealed that the soils were neutral to moderately alkaline in soil reaction and all the soil samples were found safe in electrical conductivity. The organic carbon content was low to medium in these soils. The data on free $CaCO_3$ indicates that these soils were calcareous in nature in both below and above average yield category.

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