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Assessment of soil fertility status in selected villages under Jalyukt Shivar in Nagpur district

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Abstract
This study on soil fertility status and to assess the nutrient indices of associated soils of selected villages in Nagpur district of Maharashtra was conducted during 2018-19. The villages under study were, Shemda and Umtha (Narkhed tahsil) and Dhurkheda (Katol tahsil) of Nagpur district, Maharashtra. Total 150 surface soil samples (0-20 cm) were collected, which includes 50 samples from each village. The Shemda, Umtha and Dhurkheda are clayey in texture, having bulk density 1.23 to 1.57 Mg m^{-3} and hydraulic conductivity 0.70 to 1.30 cm hr^{-1}. The soils were neutral to slightly alkaline in reaction with no salinity hazards. Low to medium in organic-C (0.20 to 0.79 %), slightly to calcareous (1.00 to 5.37 %), very low to medium in available nitrogen (107.8 to 347.6 kg ha^{-1}), medium to high in phosphorus (13.0 to 35.6 kg ha^{-1}), medium to high in potassium (254.0 to 394.0 kg ha^{-1}) and low to medium in sulphur (6.65 to 20.0 mg kg^{-1}). The soils is low to medium in DTPA-extractable iron (2.11 to 9.00 mg kg^{-1}), low to high in copper (0.18 to 1.72 mg kg^{-1}), medium to high manganese (4.02 to 8.46 mg kg^{-1}), low to high in zinc (0.20 to 1.86 mg kg^{-1}) as per three tier system of nutrient index given by Ramamoorthy and Bajaj (1969) [19].
The soils of Shemda, Umtha and Dhurkheda village were clayey in texture and had good physical condition, neutral to slightly alkaline in reaction (pH) with no salinity hazard. The soils are low to medium for available nitrogen, medium to high in available phosphorus and potassium, low to medium in available sulphur and DTPA extractable iron and low to high in zinc and copper whereas, medium to high in manganese, these are dependent of soil organic carbon level, which exhibits low to medium in range.

Keywords: Soil fertility, organic-C, DTPA-extractable, bulk density, soil texture, three tier system

1. Introduction
Soil is the source of infinite life. It is the most precious and natural resources and not renewable in short time. Soil fertility is the dynamic natural property which can change under the influence of natural and human induced factors (Denis *et al*., 2017) [10]. Soil fertility is a function of several factors such as socio-economic, ecological and for some instance, parent material, natural inputs outputs and management practices. A report of Anonymous (2000) [3] stated that about 20 per cent of the total cultivable land in the world is declining in soil fertility and impacting about a quarter of the world's population. Soil testing is important to recommend the fertilizer doses based on the fertility status of the soils to get good crop production. It provides information about the nutrient availability of the soil upon which fertilizers recommended for maximizing crop yield. A soil fertility status of a particular area can prove highly beneficial in guiding the farmers.
The study was done in Narkhed and Katol tahsil of Nagpur district which are selected through "Water foundation" under Jalyukt Shivar Programme of State Dept. of Agriculture.

2. Materials and Methods
The survey was carried out on the soil of Shemda and Umtha villages from Narkhed tahsil and Dhurkheda village from Katol tahsil of Nagpur district. The area is almost uniform plain and topography with medium to deep black soils, formed from parent material basalt. The selected villages of both the tahsil had grown the crops in *kharif* as well as in *rabi* season. Orange, cotton and soybean are the important major crops. Other than these crops wheat, jowar, rice, tur, moong, gram also taken by the farmers. Total 150 surface soil samples (0-20 cm) were collected from the selected villages of Nagpur district which includes 50 surface

soil samples from each village after harvest of crops. The collected soil samples were air dried and grind with the help of mortar and pestle and sieve through 2 mm sieve and for the determination of organic carbon, soil samples further passed through 0.5 mm sieve. These soil samples was stored in polythene bags and were subsequently analyzed for mechanical parameters such as bulk density (Blake and Hartz, 1986) [5], hydraulic conductivity (Richard, 1954) and soil texture (Bouyoucos,1936) [6], physico-chemical parameters like pH, EC (Jackson, 1973) [13], organic-C (Walkley and Black, 1934) [24], $CaCO_3$ (Piper, 1966) [18], available nitrogen (Subbiah and Asija, 1956) [23], phosphorus (Olson and Sommer,1982) [17], potassium (Jackson, 1973) [13] and sulphur (Chesin and Yein, 1951) and micronutrients like Fe, Cu, Mn and Zn (Lindsay and Norvell, 1978) [16]. The soil nutrient index was assessed by using three tier system of Ramamoorthy and Bajaj (1969) [19]. The soil nutrient index was assessed by using following formula

NI = [NL × 1 + NM × 2 + NH × 3] ÷ Total no. of samples

Where, NL, NM and NH are the number of samples in low, medium and high category of nutrient index by three tier system.

Table 1: Rating of nutrient index value (Three tier system)

Sr. no.	Category	Value
1	Low	<1.67
2	Medium	1.67-2.33
3	High	>2.33

Table 2: Critical levels of grouping of major nutrients for grouping of soils (Three tier system)

Classification for pH values			
Strongly acid	**Moderately acidic**	**Slightly acid**	**Neutral**
<5.5	5.5-6.0	6.0-6.5	6.5-7.5
Classification for total soluble salt content (EC as dSm^{-1})			
No deleterious effect on crop	Critical for germination	Critical for salt sensitive crop	Injurious to most crops
<1.0	1.0-2.0	2.0-3.0	>3.0
Parameters	**Low**	**Medium**	**High**
O.C. (%)	0.25-0.50	0.50-0.75	>0.75
Avail. N (kg ha^{-1})	<280	280-560	>560
Avail. P (kg ha^{-1})	<12.5	12.5-25	>25
Avail. K (kg ha^{-1})	<135	135-335	>335
Avail. S(mg ha^{-1})	<10	10-20	>20
Fe(mg kg^{-1})	<4.5	4.5-9	>9.0
Cu (mg kg^{-1})	<0.2	0.2-0.4	>0.4
Mn(mg kg^{-1})	<3.5	3.5-7.0	>7.0
Zn(mg kg^{-1})	<0.6	0.6-1.2	>1.2

3. Results and discussion

Physico-chemical properties

Soil texture

The analysis of soil texture was undertaken by analyzing selective 30 surface soil samples (10 samples from each village) from total 150 samples. The soils of study area are clayey in texture. The lowest content of sand was recorded at Shemda village (10.3 %) and its highest content at Dhurkheda (22.6 %). The lowest content of silt and clay was recorded at village Dhurkheda (21.6 and 48.3 %) and its highest content was recorded at Shemda (30.1 %) and Umtha (68.6 %) respectively. The soils of selected areas are developed on basaltic parent material and the soil developed on basalt produces high amount of clay on weathering (Eswaran *et al*., 1988) [11].

Bulk density and hydraulic conductivity

The bulk density is the mass of soil volume, including pore spaces (Hillel, 2000) [12]. As the bulk density relates to combined volume of the solids and pore spaces, it serves as a guide to assess the soil porosity and compaction. It can be used as an indicator for soil aeration.

The bulk density of soils of Shemda (1.27 to 1.52 Mg m^{-3}), Umtha (1.23 to 1.52 Mg m^{-3}) and Dhurkheda (1.25 to 1.57 Mg m^{-3}) indicates the soils have good aeration. The hydraulic conductivity of Shemda, Umtha and Dhurkheda varied from 0.70 to 1.36 cm hr^{-1}, 0.70 to 1.30 cm hr^{-1} and 0.70 to 1.28 cm hr^{-1} respectively.

Soil reaction (pH) and electrical conductivity

The soil pH is an indicator of the acidity or alkalinity of soil and it is an important parameter which helps in identification of the chemical nature of the soil (Shalini *et al.*, 2003) [21] as it measured the hydrogen ion concentration in the soil to indicate the acidic and alkaline nature of the soil. The pH of soil varied from neutral to slightly alkaline in reaction (6.63-8.90). The pH value of Shemda, Umtha and Dhurkheda ranged from 6.63-8.10, 7.81-8.23 and 7.09-8.50 respectively (Table 3 and 4).

The electrical conductivity (EC) is the measure of the soluble salts present in the soil and is affected by cropping sequence, irrigation, land use and application of fertilizers, manures and compost (Singh *et al.*, 2016) [22]. High value of electrical conductivity represents higher degree of salinity. The electrical conductivity of Shemda, Umtha and Dhurkheda ranged from 0.21 to 0.49, 0.21 to 0.86 and 0.22 to 0.48 dS m^{-1} respectively (Table 3 and 4).

Organic carbon

The organic carbon content of Shemda, Umtha and Dhurkheda ranged from 0.22-0.73, 0.20-0.38 and 0.25-0.79 per cent respectively. The organic carbon content of selected villages varied from low to medium in category (Table 3 and 4). Similar result was found by Chalwade *et al*., 2006 [7].

Calcium carbonate (%)

The $CaCO_3$ content of Shemda varied from 1.30-4.52 per cent, which indicates that the soils were slightly to moderately calcareous in nature, Umtha ranged from 1.0-5.0

per cent and Dhurkheda 2.12-5.37 per cent (Table 3 and 4). Similar result were reported by Lakde, (2011) [15], from Bhiwapur tahsil of Nagpur district and found that the highest value of $CaCO_3$ (11.75 per cent) in Borgaon-Rongha series, whereas lowest value (1.58 per cent) in Linga-Panjara series with mean value of 3.51 per cent.

Available macronutrients

The available nitrogen was low in major portion having the range of 107.8-347.6 kg ha^{-1} as per three tier system of nutrient index. The nitrogen content in Shemda, Umtha and Dhurkheda categorized from 107.8-321.2 kg ha^{-1}, 102.9-299.2 kg ha^{-1} and 122.5-347.6 kg ha^{-1} respectively. According to Amara *et al.* (2017), variation in nitrogen content may relate to soil management, application of FYM and fertilizers to crop. The nitrogen content in soils is dependent on temperature, rainfall and altitude.

Phosphorus is essential for growth, cell division, root growth, fruit development and early maturity of the crops. It is also required for energy storage and transfer being a constituent of several organic compounds including oils and amino acids. The level of phosphorus in study area was medium to high in category (13.0-35.6 kg ha^{-1}) i.e. in Shemda it was 14.3-32.9 kg ha^{-1}, for Umtha 13.0-30.6 kg ha^{-1} and for Dhurkheda it was 16.3-35.6 kg ha^{-1}.

Shukla (2011) found that the available potassium content generally medium to high in range. The selected villages falls under medium to high in potassium content i.e. in Shemda (266.8-392.0 kg ha^{-1}), Umtha (254.0-380.8 kg ha^{-1}) and Dhurkheda (265.0-394.0 kg ha^{-1}).

The available sulphur was low to medium as per three tier system. The sulphur content of Shemda, Umtha and Dhurkheda ranged from 9.67-18.21, 10.08-20.0 and 6.65-16.96 mg kg^{-1} respectively (Table 5 and 6). The low and medium levels of available sulphur in soils of the study area might be due to lack of sulphur addition and continuous removal of sulphur by crops (Balanagoudar, 1989) [4].

DTPA-extractable micronutrients

The DTPA-extractable iron of selected villages Shemda, Umtha and Dhurkheda was categorized under low to medium in range (2.11-9.00 mg kg^{-1}). The copper content was low to high as (0.18-1.72 mg kg^{-1}) and the manganese content was medium to high (4.02-8.46 mg kg^{-1}). Whereas, the zinc content was in low to high (0.20-1.86 mg kg^{-1}) as per three tier system of nutrient index (Table 7 and 8).

Soil fertility index and soil fertility class

The nutrient indices of soils were worked out and three tier system of soil nutrient index were assessed by using the scale of Ramamoorthy and Bajaj (1969) [19].

Soil nutrient index ratings

Considering the nutrient index values three tier system of soil organic carbon of Ramamoorthy and Bajaj (1969) [19] all the selected villages i.e. Shemda, Umtha and Dhurkheda are moderate in category i.e., 1.62, 1.46 and 1.67 respectively. The nutrient index values of three tier system of nitrogen for all the selected villages were low in category (i.e. Shemda, Umtha and Dhurkheda are 1.00, 1.14 and 1.10 respectively). The nutrient index values of available phosphorus were medium for all the villages (2.08, 1.98 and 2.10 respectively). The nutrient index values of available potassium were 2.72, 2.54 and 2.70 for Shemda, Dhurkheda and Umtha respectively which falls under high category. The nutrient index ratings for sulphur content were categorized under medium category i.e., 1.96, 2.00 and 1.82 of Shemda, Umtha and Dhurkheda respectively.

Considering the nutrient index values of three tier system for DTPA-extractable iron (Ramamoorthy and Bajaj, 1969) [19] of Shemda and Umtha was medium in category i.e., 1.74 and 1.88, while Dhurkheda was low in category (1.46). The soil of Shemda village for DTPA-extractable copper was categorized medium in category of Shemda (2.68), in Umtha and Dhurkheda were high in category i.e. 2.82 and 2.76 respectively. DTPA-extractable manganese for Shemda was high (2.12), for Umtha and Dhurkheda were medium i.e., 2.18 and 1.90 Dhurkheda. The DTPA-extractable zinc was medium in Shemda and Dhurkheda i.e., 1.76 and 1.74 respectively for and Umtha was 1.66.

Table 3: Classes of soil organic carbon and $CaCO_3$ in the soil of selected villages of Nagpur district

Organic carbon class	Organic carbon (%)	No. of samples		
		Shemda	Umtha	Dhurkheda
Low	<0.40	19	27	16
Medium	0.40-0.80	31	23	34
High	>0.80	00	00	00
$CaCO_3$ class	Available $CaCO_3$ (%)	No. of samples		
		Shemda	Umtha	Dhurkheda
Slightly calcareous	<2.5	12	31	02
Moderately calcareous	2.5-5.0	38	19	40
calcareous	>5.0	00	00	08

Table 4: Statistical data of physico-chemical properties of selected villages of Nagpur district

Properties	No. of farmers	pH		EC dSm^{-1}		$CaCO_3$ (%)		OC (%)	
Village		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Shemda	50	7.25-8.10	7.71	0.21-0.49	0.35	1.30-4.52	2.93	0.22-0.73	0.46
Umtha	50	7.21-8.30	7.70	0.21-0.86	0.45	1.0-5.0	2.38	0.20-0.68	0.40
Dhurkheda	50	7.09-8.50	7.75	0.22-0.48	0.33	2.12-5.37	4.04	0.25-0.79	0.46

Table 5: Classification of soils of selected villages of Nagpur district for available N, P, K and S

Available N class	Available N (kg ha^{-1})	No. of samples		
		Shemda	Umtha	Dhurkheda
Low	<280	47	43	45
Medium	280-560	03	07	05
High	>560	00	00	00
Available P class	**Available P (kg ha^{-1})**	**No. of samples**		
		Shemda	**Umtha**	**Dhurkheda**
Low	<12.5	00	04	00
Medium	12.5-25.0	46	43	45
High	>25.0	04	03	05

Available K class	Available K (kg ha^{-1})	No. of samples		
		Shemda	Umtha	Dhurkheda
Low	<135	00	00	00
Medium	135-335	14	23	15
High	>335	36	27	35
Available S class	**Available S (mg kg^{-1})**	**No. of samples**		
		Shemda	**Umtha**	**Dhurkheda**
Low	<10	02	00	09
Medium	10-20	48	50	41
High	>20	00	00	00

Table 6: Statistical data of available macronutrients of the selected villages of Nagpur district

Properties	No. of farmers	Macronutrient							
		Nitrogen		Phosphorous		Potassium		Sulphur	
Village		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Shemda	50	107.8-321.2	208.25	14.3-32.9	22.60	266.8-392.0	334.23	9.67-18.21	13.92
Umtha	50	102-9-299.2	187.98	13.0-30.6	20.82	254.0-380.8	307.72	10.08-20.0	13.88
Dhurkheda	50	122.5-347.6	209.85	16.3-35.6	22.57	265.0-394.0	326.36	6.65-16.96	12.79

Table 7: Classification of soils of selected villages of Nagpur district for DTPA- extractable micronutrients

Available- Fe class	Available Fe (mg kg^{-1})	No. of samples		
		Shemda	Umtha	Dhurkheda
Low	<4.5	13	06	27
Medium	4.5--9.0	37	44	23
High	>9.0	00	00	00
Available- Cu class	**Available Cu (mg kg^{-1})**	**No. of samples**		
		Shemda	**Umtha**	**Dhurkheda**
Low	<0.2	01	00	00
Medium	0.2-0.4	14	09	12
High	>0.4	35	41	38
Available-Mn class	**Available Mn (mg kg^{-1})**	**No. of samples**		
		Shemda	**Umtha**	**Dhurkheda**
Low	<3.5	00	00	00
Medium	3.5-7.0	44	41	42
High	>7.0	06	09	06
Available-Zn class	**Available Zn (mg kg^{-1})**	**No. of samples**		
		Shemda	**Umtha**	**Dhurkheda**
Low	<0.6	19	22	26
Medium	0.6-1.0	24	00	11
High	>1.2	00	07	13

Table 8. Range and average of micronutrients of selected villages of Nagpur district

Properties	No. of farmers	Micronutrients (mg kg^{-1})							
		Fe		Cu		Mn		Zn	
Village		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Shemda	50	3.23-8.95	5.59	0.18-1.29	0.56	4.05-7.72	5.40	0.20-1.56	0.75
Umtha	50	3.26-9.00	6.18	0.23-0.98	0.58	4.04-8.46	5.76	0.22-1.86	0.75
Dhurkheda	50	2.11-6.67	4.31	0.20-1.72	0.58	4.02-8.14	5.69	0.21-1.78	0.74

Table 9: Soil fertility index and fertility class of selected villages Nagpur district (three tier system)

Nutrient	Fertility index	Category
Soil nutrient index of Shemda		
Organic carbon	1.62	Low
Avail. N	1.00	Low
Avail. P	2.08	Medium
Avail. K	2.72	High
Avail. S	1.96	Medium
DTPA-Fe	1.74	Medium
DTPA-Cu	2.68	Medium
DTPA-Mn	2.12	High
DTPA-Zn	1.76	Medium
Soil nutrient index of Umtha		
Organic carbon	1.46	Low
Avail. N	1.14	Low
Avail. P	1.98	Medium
Avail. K	2.54	High
Avail. S	2.00	Medium

DTPA-Fe	1.88	Medium
DTPA-Cu	2.82	High
DTPA-Mn	2.18	Medium
DTPA-Zn	1.66	Low
Soil nutrient index of Dhurkheda		
Organic carbon	1.67	Low
Avail. N	1.10	Low
Avail. P	2.10	Medium
Avail. K	2.70	High
Avail. S	1.82	Medium
DTPA-Fe	1.46	Low
DTPA-Cu	2.76	High
DTPA- Mn	1.90	Medium
DTPA-Zn	1.74	Medium

The soils of Shemda and Umtha from Narkhed tahsil and Dhurkheda from Katol of Nagpur district were clayey in texture and had good physical condition, neutral to slightly alkaline in reaction (pH) with no salinity hazard. The soils are low to medium for available nitrogen, low to high in available phosphorus, medium to high for potassium, low to medium in available sulphur and DTPA extractable iron, medium to high in manganese and low to high in copper and zinc, these are dependent of soil organic carbon level, which exhibits low to medium in range.

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