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Soil health of soils in Aurangabad district (Maharashtra), India

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Summary

Improper agricultural practices, intensive farming with monoculture cropping pattern are responsible for deterioration of soil quality. To overcome the adverse effect of current cultivation practices, sustainable agricultural practices should be adopted. The evaluation of soil health status of Aurangabad district has been carried out with 240 surface soil samples from 12 villages of 3 blocks. The soil was analyzed for various soil fertility parameters such as pH, EC, organic matter and availability of NPK. The soils of Aurangabad district are moderately alkaline in nature with a mean value of pH 7.89. The soils are good soil with EC ranging from 0.2 to 1.70 dS/m with mean of 0.74 dS/m in Aurangabad district. The soils of Sillod block, 27.5 per cent, have to face seed emergence problem due to higher EC. The organic carbon content of soils of Aurangabad is low, mean value being 0.39 per cent. The half of the soil of Aurangabad district is having low organic carbon less than 0.40 per cent. The available nitrogen of soils of Aurangabad is low, with mean of 158.39 kg/ha. It is remarkably very low in Sillod and Aurangabad blocks. Part of Aurangabad, 52.08 per cent is very low in available phosphorus content, whereas 38.75 per cent soils have low available phosphorus content. They are very rich in potassium with a mean value of 443.60 kg/ha.There is dire need of improvement in soil organic carbon by using organic manures including intercropping, mixed cropping and adopting integrated nutrient management programme.

Key words : Crop, Fertilizers, Farmland, Macronutrients, Minerals

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Introduction

Soil is the most precious natural resource forcrop production and it takes almost 1000 years to produce an inch of top soil (Chandra and Singh, 2009). Degradation of soil hampers the productivity, which is due to natural and manmade factors. United Nations suggest that the world population by 2050 could reach 8.9 billion and at least one billion people will be chronically malnourished or starving. As human population continue to increase, human disturbance of the earth's ecosystem to produce food and fibre will place greater demand on soils to supply essential nutrients. The soils native ability to supply sufficient nutrients has decreased with higher plant productivity levels (Havlin *et al*., 2010). During green revolution period agriculture is getting more dependent upon synthetic fertilizers which are product of fossil fuel. It has adversely affected the soil, causing decrease in organic carbon, reduction in microbial flora of soil, increasing acidity and alkalinity and hardening of soil (Jain, 2009). The availability of nutrients depends on, types of soils, nature of irrigation facilities; pH and organic matter content (Gupta and Gupta, 1997). This demands development of integrated soil, crop and nutrients management technologies to enhance the plant productivity with the quality of soil, water and air. LEISA emphasize on farm nutrition management by recycling the biomass from the farm itself. This is done by adoption of crop rotation, green manure crops, intercrops, mixed cropping and crop residue mulching, farm yard manure, cow dung and cow urine based preparations as nutrients and bio pesticides, trap crops to reduce pest attacks, herbal pesticides, neem seed or leaf extract, bio pesticides and bio fertilizers, etc. Seeds should be traditional local varieties or improved/selected varieties (MOEF, 2001).

Soil health can be stated as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health. A productive soil would ensure proper retention and release of water and nutrients, promote and sustain root growth, maintain soil biotic habitat, respond to management and resist degradation. Organic carbon, organic matter and microbial biomass are direct indicator of soil biological status of soil health. Intensive agriculture has caused extraction of 10 million tons soil nutrients every year, deficiencies of secondary and micronutrients, decreasing organic carbon content, and overall deterioration in soil health. The consumption of fertilizer of Maharashtra in kg/ha are N - 74.96, P- 50.95 and K - 30.38, with NPK consumption ratio of 3.4: 2.3:1 in 2010 - 11. Site specific nutrient management involving soil test based application of fertilizers is critical to efficient utilization (Compendium on soil health, 2012). The availability of nutrients is highly influenced by pH of soil. Organic matter acts as buffering agent and after decomposing produce organic acids and CO_2, which helps to dissolve the minerals in soil.In Maharashtra, large areas are under zinc deficiency followed by iron and manganese (Malewar, 2005). Attempt has been made to evaluate the soil health of Aurangabad.

Resource and Research Methods

The study was carried out in 12 villages of Aurangabad, Phulambri and Sillod blocks of Aurangabad. The impact of sustainable agricultural practices on soil health has been evaluated by calculating adoption index using a structured questionnaire of 20 randomly selected farmers from each class from each village. The adoption index was calculated using scale developed by Supe and Singh (1975) based on low external input sustainable agriculture LEISA principles recommended by the Department of Agriculture, Maharashtra state (Supe and Singh, 1975). The farmers are classified as farmers adopting sustainable agricultural practices with LEISA principle (FSA) and farmers adopting traditional practices (FTA) according to their score. For soil health analysis 240 soil samples were tested and rated using standard methods recommended by Laboratory testing procedure for soil and water sample analysis (2009), Water Resources Department, Government of Maharashtra (Anonymous, 2009). Soil pH was determined using glass electrode pH meter (Jackson, 1973), EC by conductivity bridge (Jackson, 1973), organic carbon by modified method of Walkley and Black (1934) as described by Piper (1966), available nitrogen by alkaline permanganate method as suggested by Subbiah and Asija (1956), available phosphorus by Olsen's method (Olsen *et al.*, 1954) as described by Jackson (1973) and the potassium by flame photometer (Jackson, 1973). The results are processed statistically using SPSS 20.

Research Findings and Discussion

The soil samples were analyzed for their soil health status. The LEISA practices had significant effect on soil fertility status. Results are presented in Table 1.

pH :

The supply and solubility of most plant nutrients depend on the pH of soil. Raised quantity of some nutrients makes soil toxic for plant (Briggs, 1977). The nutrients are available to plant for maintaining soil fertility having pH between 6.5 and 7.0 (Daji, 1996). The pH range of soils of Aurangabad is 7.4 to 8.4 with mean value 7.89. This means 95 per cent soils are moderately alkaline, 2.08 per cent soils are slightly alkaline, while 2.92 per cent soils are strongly alkaline, particularly in Phulambri and Sillod blocks. The pH values of soils of FSA and FTA farmers are almost same. Waikar *et al*. (2003) reported that the soils of the same region have the pH in range of 7.4 to 8.71.

Electric conductivity :

The electric conductivity is ranging from 0.2 to 1.70 dS/m with mean value of 0.74 dS/m in Aurangabad district. There are 87.5 per cent soils with EC in range of 0.01 to 1.00dS/m considered as good. The soils face seed emergence problem are 20 per cent soils of FTAs and 7.5 per cent soils of FSAs in Sillod block, whereas 8.75 per cent soils of FTA in Aurangabad block, with EC in range of 1.1 to 1.70 dS/m. Mali *et al*. (2012) reported that EC of soils from Barhanpur, Maharashtra is in range of 0.76 to 1.24 dS/m.

Organic matter :

The organic matter improves soil health by retention of mineral nutrient, improving soil structure and water holding capacity, water infiltration, aeration, drainage and root penetration (Havlin *et al.*, 2010). It also helps to maintain large of soil flora and fauna (Jain, 2009). The organic matter is obtained by estimation of organic carbon of soil. The organic carbon content of soils of Aurangabad ranges from 0.15 to 0.90 per cent with mean value of 0.39 per cent. The half of the soil is having low organic carbon less than 0.40 per cent. The soils having medium organic carbon *i.e.* from 0.41 to 0.80 per cent are 47.92 per cent. Only 1.25 per cent soils have high organic content more than 0.80 per cent. There is no one from FSA having very low organic carbon whereas no one from FTA having high organic carbon in soils. In case of FSA maximum soil is having moderate organic carbon *i.e.* 55 per cent in Aurangabad, 70 per cent in Phulambri and 80 per cent in Sillod blocks. In case of FTA, maximum soil is having very low to low organic carbon *i.e.* 77.5 per cent in Aurangabad, 82.5 per cent in Phulambri and 100 per cent in Sillod blocks. The organic carbon level of Sillod block is lower than Aurangabad and Phulambri blocks. The soils FSA are rich in organic carbon as compared with soils of FTA. More *et al.* (1987) studied salt affected soils of Purna command in Marathwada region and found organic carbon of soils in this region is ranging from 0.48 to 0.90 per cent.

Available nitrogen :

The nitrogen forms cycle through various chains of reactions. Some free and some symbiotic bacteria fix atmospheric nitrogen in the available form of ammonium or nitrate ion, conversion of nitrogen containing compounds into humic acids, ammonification, nitrification, denitrification, leaching of nitrogen (Orlov, 1992).The available nitrogen ranges from 74.32 to 271.36 kg/ha with mean of 158.39 kg/ha *i.e.* low nitrogen content. The soils having very low available nitrogen are 38.33 per cent and low available nitrogen are 61.67 per cent. In case of FSA, soils have low nitrogen in range of 141 - 280 kg/ha. Majority FTA farmers have very low available nitrogen, *i.e.* less than 140 kg/ha. Chalwade *et al*. (2006) reported that soil samples from Marathwada are found

Table 1 : Soil health analysis of soils of Aurangabad district in 2013 - 14

Soil health parameter	Class	Unit	Range	Aurangabad		Phulambri		Sillod		District	
				FSA	FTA	FSA	FTA	FSA	FTA	FSA	FTA
pH	Slightly alkaline		7.1 to 7.5	1	1	2	1	0	0	3	2
	Moderately alkaline		7.6 to 8.3	38	39	36	38	39	38	113	115
	Strongly alkaline		8.4 to 9.0	1	0	2	1	1	2	4	3
Electric conductivity	Good soil	dS/m	0.01 to 1.00	40	330	40	39	34	24	114	96
	Poor emergence of seed	dS/m	1.1 to 2.0	0	7	0	1	6	16	6	24
Organic carbon	Very low	%	< 0.2	0	22	0	11	0	23	0	56
	Low	%	0.21 to 0.40	4	9	6	22	8	17	18	48
	Moderate	%	0.41 to 0.60	22	9	28	7	32	0	82	16
	Moderately high	%	0.61 to 0.80	11	0	6	0	0	0	17	0
	High	%	0.81 to 1.00	3	0	0	0	0	0	3	0
Available nitrogen	Very low	kg/ha	< 140	0	31	0	27	2	32	2	90
	Low	kg/ha	140 - 280	40	9	40	13	38	8	118	30
Available phosphorus	Very low	kg/ha	< 7	15	23	17	20	19	31	51	74
	Low	kg/ha	7 - 13	19	15	17	17	16	9	52	41
	Medium	kg/ha	13 - 22	6	2	6	3	5	0	17	5
Available potash	High	kg/ha	301 – 360	0	1	0	0	0	0	0	1
	Very high	kg/ha	>360	40	39	40	40	40	40	120	119

low in available nitrogen.

Available phosphorus :

The phosphorus is important part in energy transfer and storage in plant, oils and amino acids (Tandon, 1997). The fixation of phosphorus in soils having alkaline soils is major cause of lower availability of phosphorus. The soils are deficit in phosphorus in range of 6 to 22 kg/ha with a mean value of 9.10 kg/ha. The major portion of district *i.e.* 52.08 per cent is very low in available phosphorus having less than 7 kg/ha whereas 38.75 per cent soils have low in a range of 8 to 13 kg/ha and only 9.17 per cent soils are with medium. In Aurangabad block, majority FSA soils have low and majority FTA soils are very low. In Phulambri and Sillod blocks, the majority FSA and FTA soils have low available phosphorus. The medium availability of phosphorus is more in FSA than FTA soils. Ashokkumar and Prasad (2010) studied soils of Ahamadnagar district of Maharashtra and found soils with phosphorus in range of 0.6 to 28.6 kg/ha.

Available potassium :

The soils are very rich in potassium in range of 336 to 448 kg/ha with a mean value of 443.60 kg/ha. More and Gavali (2000) studied potassium of Parbhani district of Maharashtra and reported that available potassium in swell shrink soil are in range of 120 to 370 kg/ha with a mean value of 228.50 kg/ha.

The soil properties and correlation with LAISA :

The 'r' value of correlation between pH and availability of N is 0.65, 'r' value of pH and available P_2O_5 is 0.167 and'r' value of pH and available K_2O is 0.97. These 'r' values suggest there is no correlation between pH and availability of macronutrient NPK in soils of Aurangabad district. The 'r' value of correlation between pH and cotton productivity is 0.321 suggesting no correlation.

The 'r' value of correlation between EC and availability of N is 0.002, 'r' value of EC and available P_2O_5 is 0.002and 'r' value of EC and available K_2O is 0.706. These 'r' values suggest there is significant correlation between EC and availability of macronutrient N and P in soils of Aurangabad district at the 0.01 level while 'r' values of EC and K_2O suggest no correlation. The 'r' value of correlation between EC and cotton productivity is 0.065 suggesting no correlation.

The 'r' value of correlation between OC and use of FYM is 0.001 suggesting significant correlation at the 0.01 level. These 'r' values suggest there is significant correlation between OC and availability of macronutrient N and P in soils of Aurangabad district at the 0.01 level while 'r' values of EC and K_2O suggest no correlation. The 'r' value of correlation between OC and cotton productivity is 0.215; suggesting significant correlation at the 0.01 level. The 'r' values of correlations between OC and crop rotation, intercropping, mixed cropping are suggesting significant correlation at the 0.01 level. The 'r' value of correlation between OC and manual weed control at the 0.01 level is 0.02 which is significant correlation while it is of OC and use of chemical herbicide for weed control is 0.019 which is having still significant correlation in between chemical herbicide use for weed control and OC content of soil at the level of 0.05.

The 'r' value of correlation between OC of soil and farmers who are limiting their fertilizer use is 0.002 and significant at the 0.01 level. There is correlation between OC and Use of Biofertilizers, worm compost and micronutrient at the 0.01 level. The 'r' value of correlation between OC of soil and farmers using crop residue for manure making is 0.046 which is showing significant relationship at the 0.05 level. The use of biological agent for pest control, use of resistant variety, predator and parasite use for pest control and OC of soil is having significant correlation at the level of 0.01.

The correlation between available nitrogen in soil and new crop, crop rotation, intercropping, mixed cropping is significant at the level of 0.01 while it is between available nitrogen in soil and pruning, manual weed control significant at the level of 0.05. The correlation between available nitrogen in soil and farmers who are limiting fertilizer use, using micronutrient and wormy compost is significant at the level of 0.01 while it is between available nitrogen in soil and biofertilizers use significant at the level of 0.05.The correlation between available nitrogen in soil and farmers who are limiting chemical pesticide use, using pheromone trap, biological agents, predators and parasite and resistant variety for pest and disease is significant at the level of 0.01 while it is between available nitrogen in soil and chemical pesticide use significant at the level of 0.05.

There is potential to expand production efficiently for achieving food security and poverty with limiting impacts on ecosystem values. This creates scope for governments and the private sector for adoption of sustainable land and water management practices such as LEISA to promote sustainable intensification and reduce risks in production (Settle and Garba, 2011).There was great progress in agricultural productivity with the help of increased use of fertilizers, irrigation, agricultural machinery, pesticides and land during last century. Now it would be difficult to assume that these relationships will remain linear in the future. The ecological management of agro ecosystems addresses nutrient cycling, energy flows, population regulating mechanisms and resilience of system can lead to the redesign of agriculture. Sustainable Agriculture outcomes can be positive for food productivity, reduction in pesticide use and carbon balances (Pretty, 2008).

The uncontrolled use of chemical fertilizers contributes mainly to the deterioration of environment through fossil fuels depletion, Carbon dioxide (CO_2) generation and contamination of water resources and leads to loss of soil fertility impacts agricultural productivity and causes soil degradation. Now there is increasing realization that the adoption of ecological and sustainable farming can only reverse the falling trend in global productivity and environment protection (Aveyard, 1988; Wani and Lee, 1992 and Wani *et al.*,1995). Organic material such as bio-digested slurry, poultry manure, green manure and FYM can substitute for fertilizers to conserve productivity and environmental quality (Chaudhary *et al.*, 2002). The organic manures contain plant nutrients in small quantities as compared with fertilizer. Besides plant nutrients organic manure also contains growth regulators like enzymes and hormones essential for improvement of soil fertility and productivity (Bhuma, 2001).

Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time. It not only produce greater yield on a given piece of land by making more efficient use of the available growth resources but improves soil fertility through biological nitrogen fixation with the use of legumes, increases soil conservation through more ground cover and reduce pest incidence and improve forage quality by increasing crude protein yield of forage (Lithourgidis *et al*., 2011).

Soil organic matter is the critical component in the functioning of terrestrial ecosystems, providing substrate and nutrients for biotic reactions. It maintains soil structure and soil permeability and resistance to wind and water erosion. Soil organic matter is essential for carbon and nitrogen turnover and nutrient retention ultimately for soil quality. Intensive cultivation has caused a heavy loss in soil organic matter relative to natural ecosystems (Matson *et al*., 1997). Intensive cultivation is a major factor in global carbon and nitrogen balances (Vitousek *et al*., 1997 and Asner *et al*., 1997). Integrated approach for nutrient management is suggested by the scientist but it is observed that, most of the farmers are using only chemical fertilizers and they are not using organic inputs because of unavailability at local level. Organic manure includes all nutrients including micro nutrients.

Conclusion :

The evaluation of soil health status revealed that the soil of Aurangabad district is moderately alkaline in nature with pH range 7.4 to 8.4 with a mean value of 7.89. The soil is good, with EC ranging from 0.2 to 1.70 dS/m with mean of 0.74 dS/m. There are 20 per cent soils of FTAs and 7.5 per cent soils of FSAs in Sillod block, whereas 8.75 per cent soils of FTA in Aurangabad block have to face seed emergence problem. The organic carbon content ranges from 0.15 to 0.90 per cent with mean value of 0.39 per cent. The half of the soil is having low organic carbon less than 0.40 per cent. There are maximum FSA soils having moderate organic carbon whereas maximum FTA soils having very low to low organic carbon. The organic carbon level of Sillod block is lower than Aurangabad and Phulambri blocks. The soils FSA are rich in organic carbon as compared with soils of FTA. The available nitrogen of soils is low with mean of 158.39 kg/ha. It is remarkably very low in Sillod (42.5%) and Aurangabad (38.75%) blocks. Majority FTA farmers have very low available nitrogen less than 140 kg/ha.They are deficit in phosphorus in range of 6 to 22 kg/ha with a mean value of 9.10 kg/ha. The 52.08 per cent part is very low in available phosphorus whereas 38.75 per cent soils have low available phosphorus content. The medium availability of phosphorus is more in FSA than FTA soils. The soils are very rich in potassium with a mean value of 443.60 kg/ha. The organic carbon, availability of nitrogen and phosphorus of soils from FSA are more as compared with FTA. To overcome the adverse effect of current cultivation practices, sustainable agricultural practices should be adopted. There is dire need of improvement in soil organic carbon and use of organic manures with intercropping, mixed cropping and adopting integrated nutrient management programme is need of hour.

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