Original Research Article

Fertility Status of Rice growing soils of Gadchiroli Tehsil of Maharashtra in relation to available macronutrients and soil chemical properties

Abstract

The present study was undertaken to assess the status of available macronutrients, *viz.*, nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) in relation to soil chemical properties for delineating the fertility status of rice growing soils of Gadchiroli tehsil, Maharashtra. For this, fifteen villages were selected and soil samples were collected from the rice growing fields (0-20 cm depth) after the harvest of crop during the year 2020-21. The soils were found to be slightly acidic to neutral in reaction (pH 5.64 to 6.97), non-saline (EC 0.02 to 0.18 dS m^{-1}) and non-calcareous ($CaCO_3$ 0.05 to 1.15 %), with low contents of soil organic carbon (2.1 to 5.4 g kg^{-1}). The available N and S were also low, with ranges varying from 87.81 to 269.70 kg ha^{-1} for available N and 5.48 to 15.34 mg kg^{-1} for available S. The available P_2O_5 content was moderate in the soils, ranging from 23.17 to 41.98 kg ha^{-1}. The available K_2O content, however, was found to be very diversified ranging from 123.54 to 465.71 kg ha^{-1}. Correlation studies revealed a highly significant positive correlation between the macronutrients and the soil OC and EC. While, pH and free calcium carbonate showed a negative correlation with the macronutrients, except for potassium, which showed a positive and significant correlation with pH of the soil.

Keywords: *Fertility status, rice growing soils, correlation studies, available macronutrients, soil chemical properties, Gadchiroli tehsil, Maharashtra.*

1. Introduction

The fertility of soil is "its ability to provide nutrients (in adequate amount and in proper balance) for growth of plants. Soil fertility is the dynamic natural property which can change under the influence of natural and human induced factors (Denis *et al.*, 2017).

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population. It is a member of the Gramineae family. Maharashtra ranks 13th in rice production in the country. The highest productivity was observed in Konkan region, i.e., 2.56 t ha^{-1}. The area (7.32 lakh ha) of rice crop, however, is more in Vidarbha region (Thaware *et al.*, 2014). Gadchiroli, a tehsil in the Vidarbha region of Maharashtra, is known for its rice cultivation, but productivity of the area is low, despite having around 88.30 per cent of the total net sown area under paddy (Sunatkar and Dange, 2016).

Macronutrients, *viz.*, nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), are important for plant growth as they play major roles in biological processes. Continuous cropping results in removal of these nutrients, which in turn restrict crop growth and development. The continuous use of inputs such as chemical fertilizers, organic manures, insecticides and pesticides for achieving higher production, alters the chemical properties of soil and results in soil nutrient imbalance. Availability of nutrients also depends on chemical properties of the soil, which includes pH, electrical conductivity, organic carbon and free calcium carbonate content of soil.

Soil testing is the key tool, which provides information about the present nutrient status of the soil and thus help in providing site-specific recommendations of nutrients and manures, which in turn can improve crop production and productivity. Hence, the present investigation was planned to assess the fertility status of rice growing soils of Gadchiroli tehsil of Maharashtra, with special consideration to available macronutrient status and their relation with soil chemical properties.

2. Materials and Methods

A survey was conducted to identify the rice growing farmers in Gadchiroli tehsil of Maharashtra. Fifteen villages were selected covering the entire tehsil for sampling the rice growing soils. The soil samples were collected after the harvest of the crop in November 2021. A total of seventy-five surface soil samples (five samples from each village) were collected by V-cut method (0 - 20 cm depth).

The collected soil samples were air-dried and ground with the help of mortar and pestle and sieved through a 2 mm sieve. The pH and electrical conductivity (EC in dS m^{-1}) of the soil samples were determined in a 1:2.5 soil: distilled water suspension by a digital glass

electrode pH meter and a conductivity meter, respectively (Jackson, 1973). For the determination of organic carbon, soil samples were further sieved through a 0.5 mm sieve before the analysis and was estimated by Walkley and Black's (1934) chromic acid digestion method. The estimation of free calcium carbonate was done as per the rapid titration method (Piper, 1966).

Available nitrogen (N) was estimated by using the alkaline potassium permanganate method (Subbiah and Asija, 1956). Available phosphorous (P_2O_5) was extracted by Olsen's method by using 0.5 N sodium bicarbonate reagent at pH 8.5 and from the extract, concentration was estimated by using a spectrophotometer (Olsen, 1954). Available potassium (K_2O) was extracted by 1N ammonium acetate at pH 7.0 and the concentration was measured using a Flame photometer (Jackson, 1973). Available sulphur (S) was extracted from soil by using Morgan's reagent and the concentration was determined by using a Spectrophotometer as per the turbidimetric method (Chesnin and Yien, 1951). The correlation between chemical properties and available macronutrients was worked out via statistical procedures (Gomez and Gomez, 1984).

3. Results and Discussions

3.1 Chemical properties of soil

The data pertaining to the chemical properties of soils, i.e., pH, EC, OC and $CaCO_3$ are presented in Table 1. The soils of Gadchiroli tehsil were moderately acidic to neutral in reaction, with pH values ranging from 5.64 to 6.97 and a mean value of 6.36. The acidic pH of the soil may be attributed to the high rainfall received by the area under study, which resulted in leaching of the bases down the profile. Also, there might be an effect of the mixed parent material (granite, gneiss and schist) found in the region. Amongst the selected villages the highest pH was recorded in Wakadi (6.69), while the lowest pH was recorded in Pulkhal (6.03).

Table 1. Chemical properties of soils in Gadchiroli tehsil

Sr. No.	Name of village	pH	EC ($dS\ m^{-1}$)	Organic Carbon ($g\ kg^{-1}$)	Free $CaCO_3$ (%)
1.	Bodli	5.89 – 6.42 (6.19)	0.02 – 0.05 (0.03)	2.7 – 4.4 (3.2)	0.35 – 0.85 (0.66)
2.	Navegaon	6.13 – 6.34 (6.25)	0.03 – 0.14 (0.09)	2.9 – 3.6 (3.2)	0.15 – 1.15 (0.71)
3.	Murkhala	6.26 – 6.86 (6.58)	0.08 – 0.15 (0.12)	3.2 – 5.0 (3.9)	0.45 – 0.85 (0.60)
4.	Kotgal Heti	6.54 – 6.91 (6.68)	0.09 – 0.18 (0.13)	4.2 – 5.0 (4.7)	0.40 – 0.65 (0.55)
5.	Pardi Kupi	6.11 – 6.71 (6.44)	0.05 – 0.17 (0.09)	3.0 – 5.4 (4.0)	0.35 – 0.50 (0.44)
6.	Kaneri	6.12 – 6.65 (6.34)	0.03 – 0.09 (0.06)	3.0 – 4.5 (3.9)	0.45 – 0.60 (0.53)
7.	Pulkhal	5.64 – 6.65 (6.03)	0.03 – 0.07 (0.05)	4.1 – 5.0 (4.5)	0.35 – 0.75 (0.54)
8.	Wakadi	6.45 – 6.87 (6.69)	0.02 – 0.12 (0.07)	2.9 – 3.8 (3.2)	0.50 – 1.15 (0.75)
9.	Dongargaon	6.15 – 6.47 (6.34)	0.09 – 0.15 (0.12)	2.1 – 4.8 (3.6)	0.30 – 1.00 (0.51)
10.	Shioni	6.12 – 6.49 (6.29)	0.03 – 0.12 (0.07)	2.3 – 4.1 (3.0)	0.35 – 0.80 (0.54)
11.	Gogaon	5.98 – 6.81 (6.26)	0.08 – 0.14 (0.11)	3.9 – 4.7 (4.3)	0.55 – 0.90 (0.74)
12.	Sakhara	5.85 – 6.49 (6.18)	0.03 – 0.14 (0.07)	4.1 – 5.1 (4.5)	0.05 – 1.10 (0.57)
13.	Nagri	6.21 – 6.97 (6.59)	0.04 – 0.10 (0.07)	2.9 – 3.8 (3.4)	0.45 – 1.15 (0.94)
14.	Visapur	6.33 – 6.54 (6.42)	0.08 – 0.14 (0.11)	2.7 – 4.5 (3.8)	0.80 – 1.05 (0.89)

15.	Wasa Porla	6.07 – 6.21 (6.13)	0.07 – 0.15 (0.10)	3.0 – 5.0 (3.7)	0.25 – 0.85 (0.64)

Note: Figures in parenthesis show mean value.

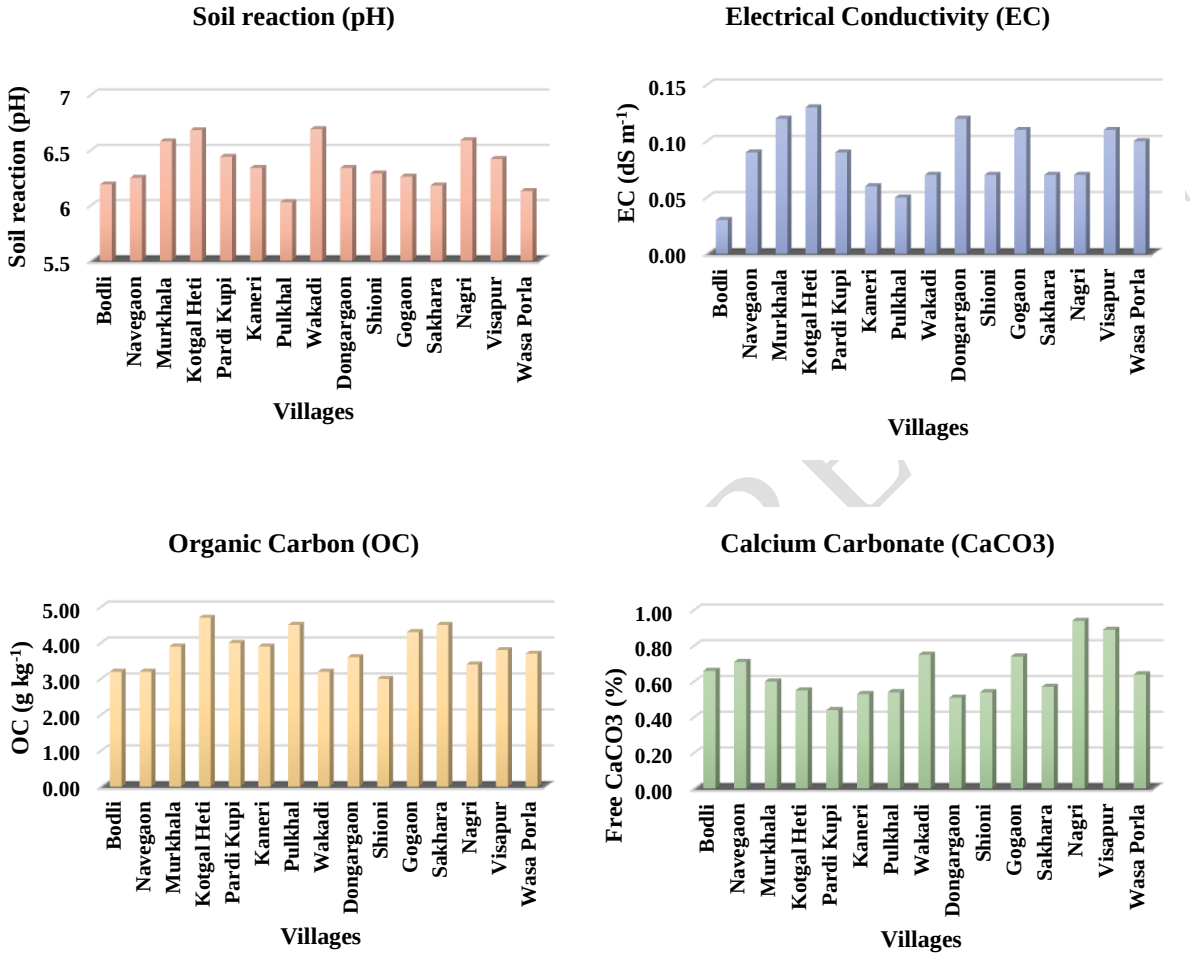

Fig. 1. Chemical properties of soils from Gadchiroli tehsil

3.2 Available macronutrient status of soil

The data regarding the status of available macronutrients in the soils of Gadchiroli tehsil are presented in Table 2. Nitrogen content in the soils varied from very low to low (87.81 to 269.70 kg ha^{-1}), with a mean value of 183.98 kg ha^{-1}. The lowest N content was found in the soils of Wakadi (139.87 kg ha^{-1}), while the highest N content was recorded from Sakhara (235.20 kg ha^{-1}). The low N content may be attributed to the low OC content of these soils, less addition of organic manures, heavy uptake of N by the improved cultivars of rice used for cultivation and loss of added nitrogenous fertilizers by leaching due to heavy rainfall. Similar observations were also reported in rice growing soils of Birbhum district in West Bengal (Mandal and Ghosh, 2021). Katkar *et al.* (2017), Patangray *et al.* (2018) and Zalte *et al.* (2018) also reported similar ranges of available N in the soils of Bhandara, Yavatmal and

Amravati (Chikhaldara tehsil) districts of Maharashtra.

The soils of the study area are low to medium in available phosphorus. Available phosphorus content in the soils varied from 23.17 to 41.98 kg ha^{-1}, with a mean value of 31.83 kg ha^{-1}. The lowest P_2O_5 content was recorded from the soils of Shioni (27.22 kg ha^{-1}), while Sakhara (37.76 kg ha^{-1}) recorded the highest P_2O_5 content amongst the selected villages. Similar ranges for available phosphorus content were reported from rice growing soils of various mandals of Krishna district of Andhra Pradesh by Subbaiah and Rajasri (2020). The soils of the study area have high clay content, which results in high P fixation, thus making it less available. The low OC content of the soils and the meagre addition of organic residues can be another reason for the low to moderate availability of phosphorus in the region. Patangray *et al.* (2018) also reported similar ranges for P_2O_5 content in soils of Kupti micro-watershed of Yavatmal district of Maharashtra.

Table 2. Available macronutrient status of soils in Gadchiroli tehsil

Sr. No.	Name Of Village	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available S (mg kg^{-1})
1.	Bodli	128.58 – 216.38 (161.19)	23.17 – 35.50 (28.57)	204.06 – 251.02 (230.89)	7.54 – 9.77 (7.74)
2.	Navegaon	147.39 – 178.75 (161.19)	25.60 – 30.71 (28.95)	230.89 – 418.74 (310.06)	7.15 – 8.82 (7.86)
3.	Murkhala	150.53 – 222.66 (176.24)	27.74 – 33.80 (30.22)	331.52 – 445.58 (381.17)	7.43 – 9.32 (8.23)
4.	Kotgal Heti	197.57 – 232.06 (219.52)	34.53 – 39.73 (37.04)	412.03 – 459.00 (434.85)	9.49 – 13.17 (11.35)
5.	Pardi Kupi	156.80 – 247.74 (185.65)	27.64 – 41.43 (32.33)	251.02 – 465.71 (335.55)	5.48 – 15.34 (9.30)
6.	Kaneri	172.48 – 232.06 (191.30)	28.05 – 36.34 (31.43)	224.18 – 459.00 (319.45)	6.76 – 11.94 (9.01)
7.	Pulkhal	200.70 – 266.56 (229.56)	34.53 – 38.68 (36.13)	324.82 – 452.29 (374.47)	8.54 – 12.50 (10.52)
8.	Wakadi	112.90 – 169.34 (139.87)	28.05 – 30.50 (29.69)	237.60 – 398.62 (293.96)	8.77 – 11.33 (10.14)
9.	Dongargaon	94.08 – 250.88 (179.38)	28.69 – 34.53 (32.20)	123.53 – 344.94 (248.33)	7.76 – 13.78 (11.07)
10.	Shioni	119.17 – 200.70 (149.90)	24.23 – 31.76 (27.22)	157.09 – 277.86 (218.82)	5.92 – 9.16 (7.67)
11.	Gogaon	200.70 – 244.61 (217.01)	28.37 – 40.26 (34.73)	197.34 – 418.74 (311.40)	9.82 – 14.84 (12.07)
12.	Sakhara	178.75 – 269.70 (235.20)	29.54 – 41.98 (37.76)	251.02 – 438.88 (318.11)	9.88 – 15.29 (13.27)
13.	Nagri	87.81 – 188.16 (144.26)	23.70 – 30.50 (28.41)	136.97 – 344.94 (255.05)	6.65 – 10.05 (8.13)
14.	Visapur	137.98 – 200.70 (174.36)	23.82 – 34.85 (29.59)	204.06 – 351.66 (272.49)	7.09 – 12.83 (10.04)
15.	Wasa Porla	169.34 – 250.88 (195.06)	28.37 – 41.66 (33.15)	136.97 – 391.91 (252.36)	7.76 – 15.23 (10.71)

Note: Figures in parenthesis show mean value.

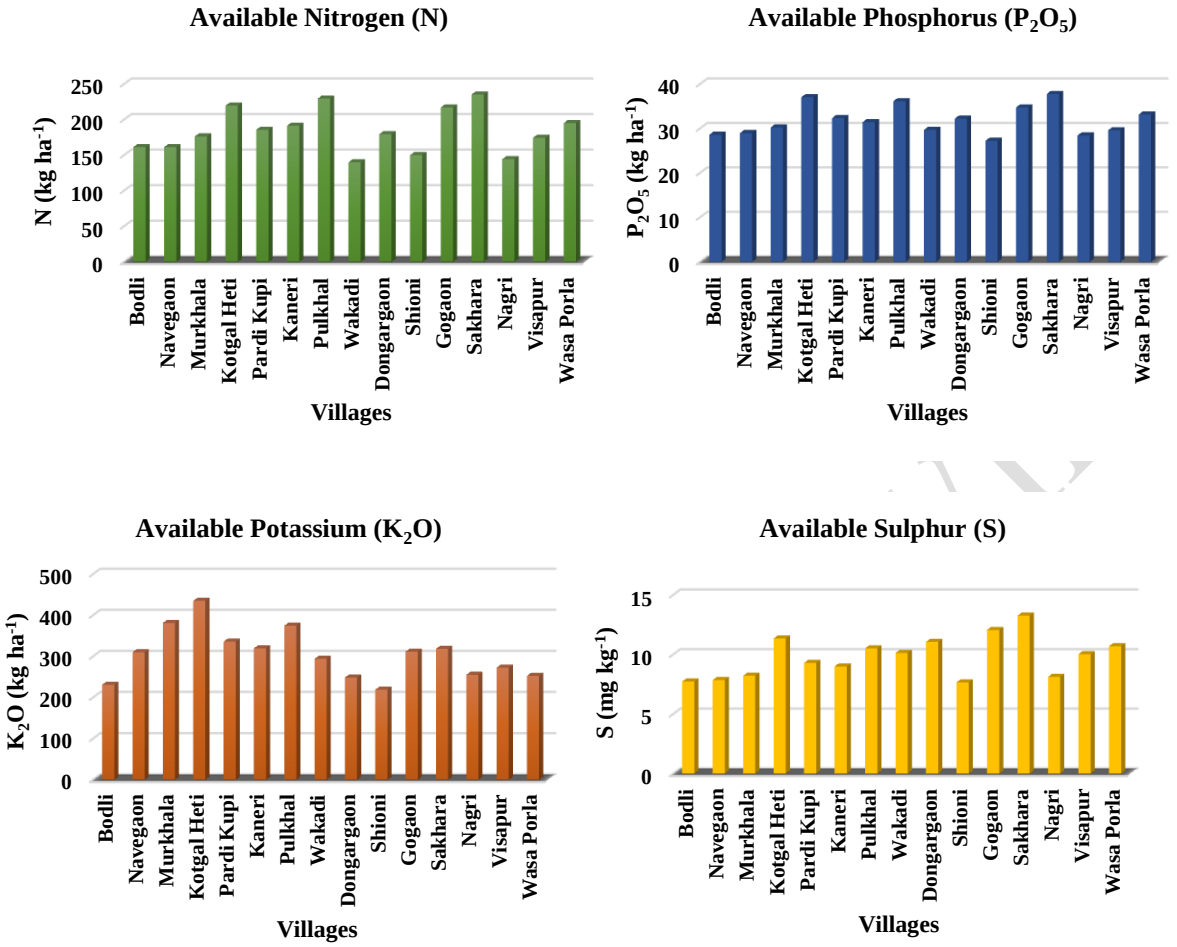

Fig. 2. Status of available macronutrients (N, P, K and S) in soils of Gadchiroli tehsil

3.2 Available macronutrient status of soil

The results on correlation between chemical properties and available nutrients in soils of Gadchiroli tehsil are presented in Table 3. The results revealed that soil pH was negatively correlated with available N (r = -0.300**), available P_2O_5 (r = -0.057) and available S (r = -0.036), but the correlation was significant only in the case of available N. Available K_2O (r = 0.297**), however, showed a positive significant correlation with soil pH. The EC of the soil was positively and significantly correlated with the macronutrients, i.e., available N (r = 0.300**), available P_2O_5 (r = 0.355**), available K_2O (r = 0.447**) and available S (r = 0.367**). A highly significant and positive correlation was also observed between OC and availability of macronutrients, viz., N, P_2O_5, K_2O and S, with correlation values of r = 0.921**, r = 0.889**, r = 0.762** and r = 0.691**, respectively. This may be attributed to the release of plant essential nutrients on mineralization of organic matter leading to the availability of the macronutrients. The free $CaCO_3$ content of soil, on the other hand, showed a significant and negative correlation with nitrogen (r = -0.354**) and phosphorus (r = -0.235*), while it showed a non-significant negative correlation with potassium and sulphur with r values of -0.179 and -0.171, respectively.

Table 3. Correlation coefficient (r) between soil chemical properties and available macronutrients

	Avail. N	Avail. P_2O_5	Avail. K_2O	Avail. S
pH	- 0.300**	- 0.057	0.297**	- 0.036
EC	0.300**	0.355**	0.447**	0.367**
OC	0.921**	0.889**	0.762**	0.691**

$CaCO_3$	- 0.354**	- 0.235*	- 0.179	- 0.171

4. Conclusions

Based on overall results gathered from the present investigation, it can be concluded that the soils of the selected villages of Gadchiroli tehsil were slightly acidic to neutral in reaction, with little or no harm from soluble salts and free calcium carbonate in the soil. Among the macronutrients, available nitrogen was found to be deficient (very low to low), phosphorus and sulphur content varied from low to moderate levels, while potassium content was found to fluctuate between low to very high values. Correlation studies revealed that the low OC content and acidic pH is the main constraints of the region. Thus, the soils of Gadchiroli tehsil were found to be low in fertility, which require immediate attention. Addition of organic residues, optimal fertilizer management, increased use of organic manures and proper management practices are prerequisite for improving and sustaining the fertility status of the region under study.

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