www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(8): 06-10

www.thepharmajournal.com
Received: 08-05-2023
Accepted: 12-06-2023

MM Sreelakshmi
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Kerala Agricultural University, College of Agriculture, Vellayani, Trivandrum, Kerala, India

B Aparna
Professor and Head, Department of Organic Agriculture, Kerala Agricultural University, College of Agriculture, Vellayani, Trivandrum, Kerala, India

Rani B
Professor and Head, Department of Soil Science and Agricultural Chemistry, Kerala, India

Biju Joseph
Associate Professor, Department of Soil Science and Agricultural Chemistry, Rice Research Station, Moncompu, Kerala Agricultural University, Kerala, India

Bindhu JS
Assistant Professor, Department of Agronomy, Integrated Farming Systems Research Station, Karamana, Kerala Agricultural University, Kerala, India

Binitha NK
Assistant Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Padanakkad, Kerala Agricultural University, Kerala, India

Corresponding Author:
MM Sreelakshmi
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, Kerala Agricultural University, College of Agriculture, Vellayani, Trivandrum, Kerala, India

Dynamics of macro nutrients in detrital laterite soils of northern Kerala

MM Sreelakshmi, B Aparna, Rani B, Biju Joseph, Bindhu JS and Binitha NK

Abstract
The current study investigated the dynamics of major nutrients in eight major soil series of Agro ecological Unit 11 of northern Kerala. Kalikkadavu series recorded the highest mean value for available N at 0-15 cm and 15-30 cm soil depth. A decreasing trend in available N was observed with increase in soil depth. Payalam series showed the highest value for Available P and it varied from 13.56-48.73 kg ha^{-1}. The lowest value of 13±1.33 kg ha^{-1} was observed in Naduvattom series. Available K of Arathil series was found the highest with mean values of 397.6 kg ha^{-1} and 497.28 kg ha^{-1} at a depth of 0-15 cm and 15-30 cm respectively. In surface soils, Payalam series recorded the highest calcium content with a mean value of 534±86.94 mg kg^{-1} whereas Kalikkadavu recorded the lowest with a mean value of 318±17.52 mg kg^{-1}. Arathil series recorded the highest value with a mean value for available Mg at both depths. Angadipuram series recorded the highest mean value for available S at 0-15 cm depth and it varied from 15.5-360 mg kg^{-1} within the series. To conclude, it was observed that the dynamics of primary as well as secondary nutrients exhibited variation in the major lateritic soil series of northern Kerala. The nutrient classes of surveyed samples was found medium to high for available N, available P, and low to high for available K content. Deficiency of Ca, Mg, and S were also prevalent in the study area. Hence, we recommend a proper nutrient management for wetland rice cultivation in detrital laterite derived rice fields.

Keywords: Nutrient dynamics, detrital laterites, soil nutrients, wetlands

1. Introduction

In laterite profiles of Kerala, laterization occurs in two stages *viz* sudden depletion of silica, alkali and alkaline earth materials and gradual depletion of silica, alkali and alkaline earth materials, accompanied by enrichment of Fe, Al, and Ti (Prasad and Parthasarathy, 1993) [9]. The entire state of Kerala is thus covered by more than seven soil orders with a significant share constituted by Ultisols.

Kaolinite is the most prevalent clay mineral in laterite soil. Recent investigations have suggested that laterites that have fully grown are really an indurated Fe crust known as plinthite. Micronutrient deficiencies, low CEC, excess Fe, Al, and Mn, as well as a lack of organic matter, N, P, K, calcium, magnesium, and sulphur, are the main chemical limitations. For crop productivity, notably rice cultivation in Kerala, Fe and Al toxicity remain major challenges. Tropical laterites have lower levels of organic matter and nitrogen because of the extreme temperatures and frequent rains. Fe and Al phosphates are formed in mature laterites when Fe and Al interact with phosphates in soil. The presence of high concentrations of Fe and Al in soil hinders the absorption of other nutrients leading to poor nutrient use efficiency (Ghosh and Patra).

For increasing the food grain production and meeting global food demand, it is imperative to know the nutrient dynamics of laterite derived wetland soils to adopt effective nutrient management strategies. Hitherto there is a plethora of research on soil acidity, limited works have been carried out to study the nutrient dynamics of detrital laterite of tropical soils. Hence, the current study was conducted to explore the nutrient dynamics of detrital laterite rice wetlands of Kerala.

2. Materials and Methods

After a preliminary survey, 160 geo-referenced soil samples were collected from the rice-based detrital laterites derived wetlands. The soil samples were collected from respective plots by random sampling technique.

They were dried in shade, powdered with a wooden mallet, sieved using a 2 mm sieve, and stored in polythene bags for carrying out for nutrient analysis. Available N was determined using alkaline permanganate method. After Bray No.1 extraction, available P was determined using Double Beam UV-VIS Spectrophotometer. Similarly available potassium (K) was estimated using neutral normal ammonium acetate extraction followed by flame photometry. Available calcium (Ca) and magnesium (Mg) were determined using an atomic absorption spectrophotometer.

3. Results and Discussion

3.1 Available N

All samples of Kunnathura, Payalam, Kalikkadavu, Nanminda, and Kunamangalam reported high nitrogen content. In Naduvatom, 10% fall in low category, 40% in medium category and 50% of samples were found high while in Arathil, majority of samples (60%) had medium, 10% medium and 10% high available N content (Table. 1). Kalikkadavu series recorded the highest mean value of 889.37±50.6 kg ha^{-1} at 0-15 cm depth and 841.37±50.7 kg ha^{-1} at 15-30 cm soil depth. The highest value in Kalikkadavu might be attributed by high organic carbon content (1.19 % and 1.05% at 0-15 and 15-30 cm respectively). High rate of nitrogen mineralization due to high microbial activity also contributes to high N content in these series (Bowles *et al.*, 2014) [2]. The lowest value was observed in Arathil series with a mean value of 299.802±138.8 kg ha^{-1} and 279.8±128.7 kg ha^{-1} at 0-15 cm and 15-30 cm depth respectively. A decreasing trend in available N was observed with increase in soil depth. This is in concordance with the decreasing trend in organic carbon down the profile.

Table 1: Soil available N (kg ha^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	701.21±200.80	376.32-965.89	696.2±170.46	413.93±953.30
Naduvattom	558.21±189.82	225.73-852.99	337.43±195.13	87.81-577.02
Kunnamangalam	713.75±75.12	589.57-802.82	713.7±75.83	589.87-802.82
Nanminda	811.60±141.43	639.74-965.89	800.6±141.5	623.74-945.89
Kalikkadavu	889.37±50.62	840.45-965.89	841.37±50.7	826.45-960.89
Arathil	299.80±138.84	87.81-564.48	279.8±128.7	86.87-512.90
Kunnanthura	594.48-627.22	565.84±997.24	552.52±612.25	227.76-971.5
Payalam	835.43±24.52	802.82-890.64	822.47±34.7	800.91-890.63

Table 2: Soil available P (kg ha^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	14.70±0.82	13.01-16.24	10.22±0.94	9.01-11.32
Naduvattom	13.24±1.33	3.82-29.83	11.32±1.49	9.04-13.01
Kunnamangalam	27.34±10.19	15.67-39.12	14.07±3.42	10.27-17.31
Nanminda	19.67±8.32	13.26-41.46	18.43±0.67	17.31-19.18
Kalikkadavu	18.97±6.2	11.21-34.67	17.52±5.72	8.86-27.62
Arathil	24.56±11.36	2.29-39.36	18.26±7.80	12.8-26.45
Kunnanthura	16.62±3.75	13.56-44.15	99.68±9.81	75.32-105.83
Payalam	27.91±9.36	13.56-48.73	18.22±2.39	13.56 -20.59

3.2 Available P

Available P content was observed medium in most of the survey samples. A wide P deficiency was observed in Arathil series. From the data presented in Table.2, Payalam series showed the highest value for Available P and it varied from 13.56-48.73 kg ha^{-1}. The lowest value of 13±1.33 kg ha^{-1} was observed in Naduvattom series. Relatively low P content in theses soils might be due to high acidity and presence of sesquioxides hampering the available P as Fe and Al phosphates. Freshly precipitated hydroxyl phosphates thus formed are slightly soluble and P is slightly available to plants, because they have a great deal of surface area exposed to the soil solution (Ghosh, and Patra, 2012) [5]. Adsorption of P by soluble Al occurs in strongly acidic soil where soluble Al predominates (Das, 2011). Dinesh *et al.* (2014) also reported the P fixation is high in acidic laterite soils of Kerala.

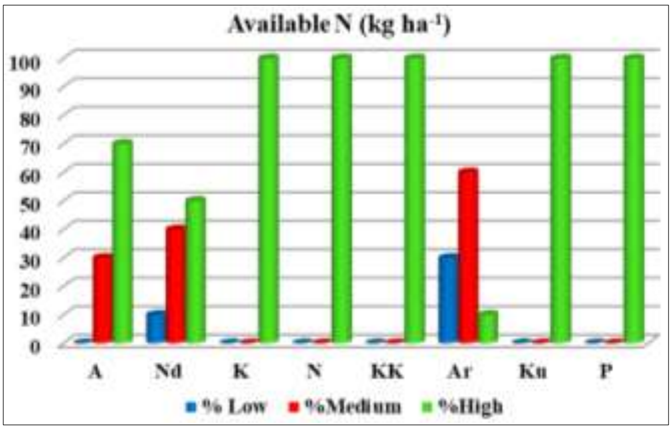

Fig 1: Frequency of available N classes in eight major soil series of AEU 11

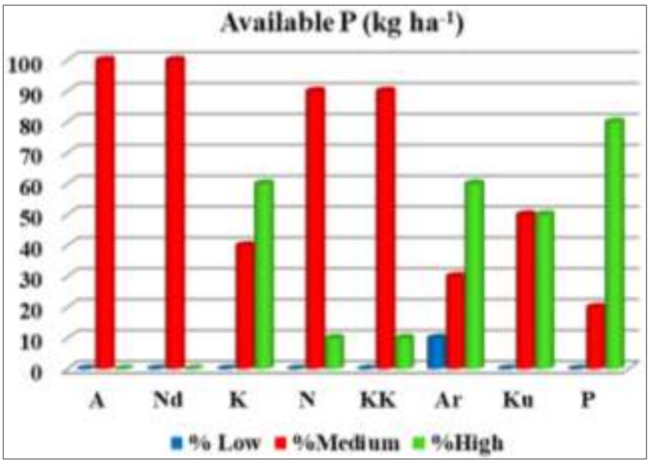

Fig 2: Frequency of available P classes in major eight soil series of AEU 11

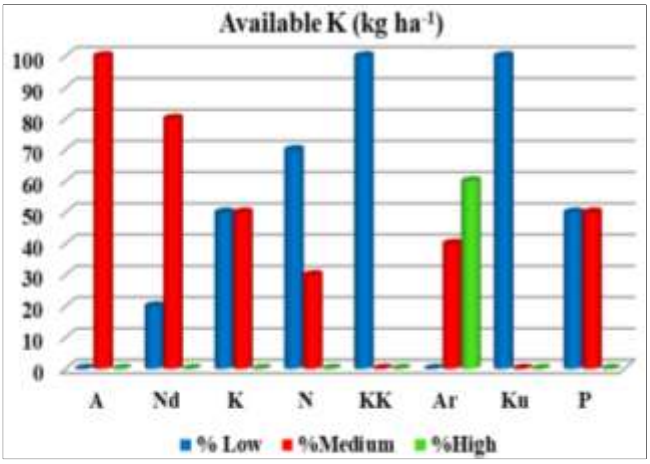

Fig 3: Frequency of available K classes in eight major soil series of AEU 11

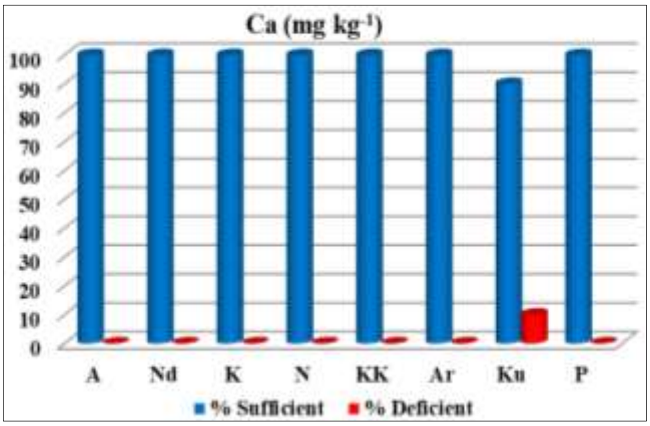

Fig 4: Frequency of available Ca classes in major eight soil series of AEU 11

3.3 Available K

A wide potassium deficiency was observed in the surveyed samples. All samples of Kunnanthura and Kalikkadavu, 20% of Naduvattom, 50% of Kunnamngalam, and 70% of Nanminda were found deficient in K while 60% of Arathil series recorded sufficient available K. All other sample in all series had medium K content. Available K of Arathil series was found the highest with mean values of 397.6 kg ha^{-1} and 497.28 kg ha^{-1} at a depth of 0-15 cm and 15-30 cm respectively. High exchangeable cations, clayey texture of soil, parent material rich in K might be reasons for this (Dey *et al*., 2017) [4]. Similar findings are reported by (Mouhamad *et al*., 2016) [8]. High K content in these soils might also be due to stubble and straw incorporation which decomposes and release K to soil. Kalikkadavu series recorded the lowest value at 0-15 cm soil depth whereas Kunnanthura series recorded the lowest value at 15-30 cm soil depth. High sand content and less clay fraction and low CEC might be the primary reasons for this (Römheld and Kirkby, 2010) [10].

Table 3: Soil available K (kg ha^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	224.14±93.15	212.83-235.22	185.92±144.95	168.11-201.60
Naduvattom	136.64±43.10	112.11-257.63	105.39±10.82	89.60-123.24
Kunnamangalam	155.68±85.04	56.25-268.82	78.41±39.51	33.62-168.21
Nanminda	109.76±11.57	89.60-123.21	136.64±67.98	56.01-257.60
Kalikkadavu	80.64±27.83	44.80-112.14	61.62±15.16	44.80-78.40
Arathil	397.60±121.19	257.14-504.01	497.28±45.18	448.11-560.14
Kunnanthura	89.61-112.24	57.12±97.01	39.64-78.40	31.23±84.45
Payalam	124.32±23.87	100.82-156.8	120.96±38.37	78.40-168.14

Table 4: Soil available Ca (mg kg^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	380.24±12.45	374-386	384.02±1.11	312-399
Naduvattom	460.12±5.16	452-468	474.80±11.23	460-489
Kunnamangalam	406.21±26.75	360-440	530.24±81.76	460-700
Nanminda	514.12±158.62	360-740	494.00±129.63	360-680
Kalikkadavu	318.36±17.52	300-340	402.91±81.35	320-580
Arathil	522.14±38.24	460-580	738.12±331.24	660-920
Kunnanthura	354.28±78.9	260-500	69.68±53.9	20-440
Payalam	534.3286.94	420-640	636.33±226.1	420-980

3.4 Available Ca

90% of Kunnanthura series exhibited sufficient Ca content while for other series, all samples had sufficient Ca content. In surface soils, Payalam series recorded the highest calcium content with a mean value of 534±86.94 mg kg^{-1} whereas Kalikkadavu recorded the lowest with a mean value of 318±17.52 mg kg^{-1} (Table.4). The higher value of Ca in the sampled location might be due to continuous application of liming materials to ameliorate to acidity, Fe and Al toxicity (Rowley *et al.,* 2018) [11]. At a depth of 15-30 cm, the highest mean value of 1038±331.24 mg kg^{-1} was observed in Arathil series whereas the lowest value was observed in Kunnanthura series with an average value of 69.6±53.9 mg kg^{-1}. Low calcium content might be due to acidic soil reaction, high exchangeable acidity, and sandy texture of soil which leads to calcium leaching (Kidd and Proctor, 2001) [7].

3.5 Available Mg

Deficiency of Mg was observed in Kunnamnagalam, Nanminda, Kalikkadavu, Kunnanthura and Payalam series with a magnitude of 100, 30, 70, 70, and 70 % respectively. Arathil series recorded the highest value with a mean value of 588±201.43 mg kg^{-1} at 0-15 cm depth and 838.8±434.38 mg kg^{-1} at 15-30 cm depth. Soil samples from Kunnamangalam series recorded the lowest value at 0-15 cm depth with an average of 43.2±20.55 mg kg^{-1} while Kunnanthura recorded the lowest mean value of 3.3±5.69 mg kg^{-1} at 15-30 cm depth. (Gransee, and Führs, 2013) [6] reported that Mg is more soluble and readily available at optimum pH. In acidic soils, Mg deficiency is attributed by instability of Mg minerals. Parent material, intensity of weathering, soil pH, soil moisture and microbial activity determines the availability of Mg in laterite soil (Senbayram *et al.*, 2015) [13].

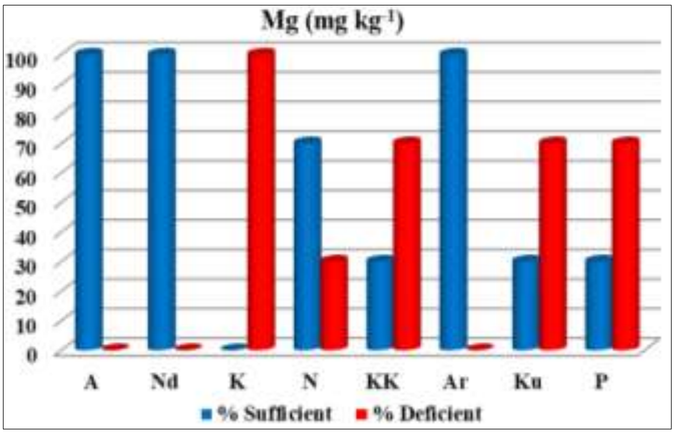

Fig 5: Frequency of available Mg classes in major eight soil series of AEU 11

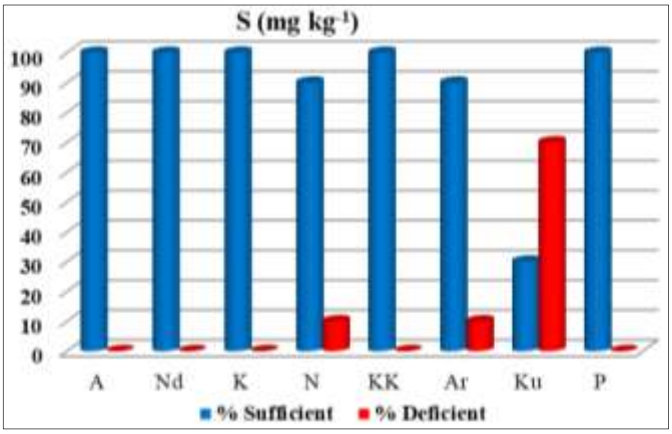

Fig 6: Frequency of available S classes in major eight soil series of AEU 11

Table 5: Soil available Mg (mg kg^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	385.01±1.11	383±386	300.21±14.14	280±320
Naduvattom	302.22±13.98	280±320	306.02±12.64	301±12.64
Kunnamangalam	43.20±20.55	29±221	139.28±57.18	96±252
Nanminda	142.84±47.48	60±192	195.69±124.97	24±232
Kalikkadavu	106.84±14.37	84±132	63.64±47.68	12±144
Arathil	588.32±201.43	252±816	838.81±434.38	372±890
Kunnanthura	104.47±58.52	79±168	46.34±5.69	36±204
Payalam	415.23±605.61	12±533	100.83±127.24	78±369

Table 6: Soil available S (mg kg^{-1}) at two different depths of 0-15 cm and 15-30 cm.

Soil series	0-15 cm		15-30 cm	
	Mean ± SD	Range	Mean ± SD	Range
Angadipuram	50.85±107.63	15.51-360.01	20.05±2.92	16.01-24.21
Naduvattom	22.75±0.26	22.52-23.11	23.25±1.18	21.12-25.24
Kunnamangalam	11.25±4.38	4.53-15.01	9.08±3.72	2.57-15.09
Nanminda	15.53±47.91	2.58-25.09	12.77±15.92	1.14-45.09
Kalikkadavu	13.11±15.27	5.06-56.02	15.50±25.76	3.57-88.33
Arathil	12.81±10.56	1.53-40.14	9.72±3.94	6.09-16.09
Kunnanthura	36.10±36.90	7.08-16.14	8.01±8.03	5.32-13.07
Payalam	10.12±8.23	5.01-25.36	6.55 7.94	1.04-20.00

3.6 Available S

70% of Kunnanthura series samples, 10% of Ararthil and Nanminda series exhibited S deficiency. Sulphur deficiency might be due to formation of insoluble FeS under submerged condition (Biswas *et al.*, 2015) [1]. It might be also due to leaching loss of S in sandy soils (Scherer, 2001) [12]. Other samples has shown medium to high level of S. Angadipuram series recorded the highest mean value for available S at 0-15 cm depth and it varied from 15.5-360 mg kg^{-1} within the series. High sulphur content in sampled location might be due to presence of iron pyrites and iron bearing minerals like jarosite (Brown, 1982) [3]. Also, the continuous application of sulphur containing fertilizers like ammonium phosphate sulphate might attribute to this. The lowest value at the same depth was observed in Payalam series. At 15-30 cm depth, Naduvattom series recorded the highest value. This might be due to the fact that organic matter supplies amble amount of S to soil by mineralisation process and S exists predominantly in organic form (Uchimiya *et al*., 2010) [14].

4. Conclusion
From the current study, it was observed that the dynamics of primary as well as secondary nutrients exhibited variation in the major lateritic soil series of northern Kerala. The variation in nutrient availability was observed within the series and down the soil profile. The nutrient classes of surveyed samples fall was found medium to high for available N, available P, and low to high for available K content. Deficiency of Ca, Mg, and S were also prevalent in the study area. Hence, we recommend a proper nutrient management for wetland rice cultivation in detrtital laterite derived rice fields.

5. Acknowledgement
The authors would like to thank the laboratory and field staff at the College of Agriculture, Vellayani, Kerala for their assistance to this project. Financial support for this research was provided by the Kerala Agricultural University grants (Acad.A2/3378).

6. Conflict of interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. Author contributions
Sreelakshmi. M. M: Conceptualization, Methodology, Formal analysis, Investigation, Writing the original draft, Critical Review and Editing, Visualization, Validation, Project Administration
Aparna. B: Conceptualization, Methodology, Resources, Validation, Project Administration, Supervision
Rani. B: Conceptualization, Methodology, Resources, Validation, Project Administration, Supervision
Biju Joseph: Conceptualization, Methodology, Resources, Validation, Project Administration, Supervision
Bindhu J S: Conceptualization, Methodology, Resources, Validation, Project Administration, Supervision
Binitha. N. K: Conceptualization, Methodology, Resources, Validation, Project Administration, Supervision

8. References
1. Biswas BC, Sarkar MC, Tanwar SPS, Das S, Kalwe SP. Sulphur deficiency in soils and crop response to fertilisersulphur in India. Fertil. News. 2004;49(10):13-33.
2. Bowles TM, Acosta-Martínez V, Calderón F, Jackson LE. Soil enzyme activities, microbial communities, and carbon and nitrogen availability in organic agro ecosystems across an intensively-managed agricultural landscape. Soil Biol. Biochem. 2014;68:252-262.
3. Brown KA. Sulphur in the environment: a review. Environ. Pollut. Series B Chem. Phys. 1982;3(1):47-80.
4. Dey P, Santhi R, Maragatham S, Sellamuthu KM. Status of phosphorus and potassium in the Indian soils vis-à-vis world soils. Indian J Fertil. 2017;13(4):44-59.
5. Ghosh SK, Patra PK. Distribution of different forms of phosphorus in surface soils of rice growing areas of red and laterite zone of West Bengal. J Indian Soc. Soil Sci. 2012;60(3):204-207.
6. Gransee A, Führs H. Magnesium mobility in soils as a challenge for soil and plant analysis, magnesium fertilization and root uptake under adverse growth conditions. Plant Soil. 2013;368:5-21.
7. Kidd PS, Proctor J. Why plants grow poorly on very acid soils: are ecologists missing the obvious? J Exp. Bot. 2001;52(357):791-799.
8. Mouhamad R, Alsaede A, Iqbal M. Behavior of potassium in soil: A mini review. Chem. Int. 2016;2(1):58-69.
9. Prasad TK, Parthasarathy GR. Laterite and laterization-a geomorphological review. Int. J Sci. Res. 2018;7(4):578-583.
10. Romheld V, Kirkby EA. Research on potassium in agriculture: needs and prospects. Plant Soil. 2010;335:155-180.
11. Rowley MC, Grand S, Verrecchia EP. Calcium-mediated stabilisation of soil organic carbon. Biogeochemistry. 2018;137(1-2):27-49.
12. Scherer HW. Sulphur in crop production. Eur. J Agron. 2001;14(2):81-111.
13. Senbayram M, Gransee A, Wahle V, Thiel H. Role of magnesium fertilisers in agriculture: Plant-soil continuum. Crop Pasture Sci. 2015;66(12):1219-1229.
14. Uchimiya M, Lima IM, Klasson KT, Wartelle LH. Contaminant immobilization and nutrient release by biochar soil amendment: roles of natural organic matter. Chemosphere. 2010;80(8):935-940.