Journal of Experimental Agriculture International

44(9): 27-34, 2022; Article no.JEAI.86342
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Potassium Forms in Brown Sarson Growing Soils in District Kupwara, Kashmir

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2022/v44i930846

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86342

Original Research Article

Received 20 February 2022
Accepted 25 April 2022
Published 20 May 2022

ABSTRACT

Distribution of different forms of potassium and their correlation with soil physico-chemical properties was studied in Brown Sarson growing soils of district Kupwara. The study was carried out to pave a way for drafting proper fertilization plan keeping in view the importance of potassium for crops and reluctance of farmers in applying the same. The study area was divided into two regions i: e upper belt and lower belt and surface soil samples (0-25 cm), ten from each belt were collected for analysis. The soil samples collected were studied for potassium forms and physico- chemical properties. The soils analyzed were clay loam to loamy in texture and acidic to neutral in reaction. The organic carbon content was higher in lower belts as compared to upper belts. The potassium fractions followed an order total-K > lattice-K > acid soluble-K > non exchangeable- K> available-K> exchangeable-K> water soluble-K. All forms of K were positively correlated to organic carbon, cation exchange capacity and clay content and negatively correlated with pH and calcium carbonate.

Keywords: Brown sarson; soils; potassium fractions; physico-chemical properties; correlation.

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1. INTRODUCTION

Potassium (K) is the essential macro plant nutrient element that plays a vital role in all metabolic activities like enzyme activation, protein synthesis, ion absorption & transport, photosynthesis and respiration [1]. It is one of the most abundant nutrients in soil with its amount depending upon parent material, degree of weathering, fertilizer application, leaching and erosive losses. Potassium occurs mainly in four different forms soil solution K, exchangeable K, fixed K, structural K [2] and among these soil solution K and exchangeable K is important in terms of availability to plants [3]. Non-exchangeable and mineral K are slowly available forms. There exists a dynamic equilibrium between forms of potassium [4] but the actual amount of potassium that occurs in solution form is very low and must be replenished by exchangeable form or by some other means [5]. However, the application of soil potassium for nutrient requirements of crops is mostly neglected by farmers in India due to its increasing cost [6]. There exists a negative balance of this element which is increasing interest in the non-exchangeable or fixed forms of potassium. The soils of Kashmir owing to the predominance of K-rich illitic minerals are abundant in potassium. But unfortunately only a small portion of it becomes available to the plants especially under temperate climatic conditions of Kashmir. The deficiency of it causes a great reduction to yield in most of the crops especially in crops like Brown Sarson that need an adequate amount of potassium for better yield and quality [7]. Although brown Sarson forms an important Rabi crop of Kashmir valley, farmers of the study area are reluctant towards application of potassium and give preference to nitrogen and phosphorus fertilizers only. Now the need of time is to get a deep insight about the need for external application of potassium fertilizer to and what quantity of fertilizer must be applied in brown Sarson growing areas. Knowledge of different forms of potassium in soil together with their distribution would be of great relevance in assessing the long term availability of K to crops in general [8] and in formulating a sound basis of fertilizer recommendation for brown Sarson crop. Not only fractions but, it is important to study the relationship between soil properties and K fractions in addition to its distribution in different forms because the dynamics of potassium in soils is governed by physico-chemical properties of soils. Hence, the present study was planned to get insights into potassium fractions in brown sarson growing soils of District Kupwara in Kashmir valley.

2. MATERIALS AND METHODS

The study was conducted in District Kupwara which lies in the north of Kashmir Valley. The area was divided into upper belts ranging from 1650-1850 meters above mean sea level (amsl) and lower belts ranging from 1550-1650 meters amsl. The composite samples were analyzed for various physico chemical properties and different forms of potassium replicated three times. The Soil pH, electrical conductivity (EC) and cation exchange capacity (CEC) were determined by standard procedure laid down by Jackson [9]. The Organic carbon (OC) was analyzed by oxidation of organic matter by potassium dichromate as laid down by Walkley and Black [10]. The particles size analysis was performed by method given by Piper [11]. Water soluble potassium was determined by shaking 1:5 mixture of soil and water for 5 minutes and quantifying K of saturation past extract. Available K was estimated by a procedure laid down by Jackson [12] after shaking soil with 1 N ammonium acetate (pH 7.0). Exchangeable K was obtained by subtracting water- soluble K from available K [13]. Fixed K was extracted from soil by boiling with 1 N HNO_3 and Total K was extracted by using HF-$HClO_4$ in a platinum crucible following procedure of Pratt [14].

Lattice K was determined by subtracting 1 N HNO_3 soluble K from the total K. The data was subjected to descriptive analysis and correlation was worked in OPSTAT software.

3. RESULTS AND DISCUSSION

3.1 Physico Chemical Properties

All the soils analyzed were fine textured (loamy to clayey). In soils of upper belts (1650-1850 amsl) sand, silt and clay fractions ranged from 23.56% to 37.00 %, 38.0% to 44% and 22.19 % to 37.67% respectively (Table 1). In case of lower belts most of soils had a loamy texture with sand percentage ranging from 22 to 50 %, silt from 20 to 46 % and clay from 16.75 to 32 %. Similar results were reported by Irshad et al. [15] while studying soils in altitudes ranging from 1580 to 3000m above mean sea level in district Ganderbal of North Kashmir. All the soils were acidic to neutral with pH ranging from 5.30 to 6.80 with mean a value of 6.09 for upper belts and 6.01 for lower belts (Table 1). This decrease in soil pH with decreasing altitude might be attributed to presence of higher organic matter in lower belts which releases organic acids on decomposition. The EC of the soils in general was of normal value with a range of 0.11 to 0.15. The mean value of EC was 0.14 and 0.15 in upper and lower belts respectively (Table 1). Alaie et al. [16] reported similar results for soil EC in some soils of North Kashmir. It exhibited a decreasing trend with increase an in elevation, which may be attributed to leaching of soluble salts from higher elevation [17]. The organic carbon content in soils ranged from 1.03-2.29 % in upper belts and 1.66-2.32 in lower belts. The mean value of organic carbon was 1.57% for upper belts and 1.96 % for lower belts. Similar results were reported by Baba et al. [18] and Ahad et al. [19] while quantifying organic carbon content in soils of district Kupwara. The cation exchange capacity ranged from 16.90 to 19.96 C mol (p^+) in upper belts kg $^{-1}$17.21 to 20.57 C mol (p^+) kg $^{-1}$ in lower belts. The higher value of CEC in lower belts may be due to the higher amount of organic matter present in lower belts as it is well-established fact that presence of organic matter in soil has a positive impact on its CEC [20].

3.2 Forms of Potassium

The water-soluble K ranged from 5.50 to 11.50 mg kg^{-1}with a mean value of 7.35 mg kg^{-1}for upper belts and 7.70 mg kg^{-1}for lower belts. Available -K ranged from 27.09 to 149 mg kg $^{-1}$ with mean 54.10 and 57.00 mg kg $^{-1}$ for upper and lower belts respectively (Table 2). The higher value for available K in lower belts may be attributed to presence of illitic clays as earlier reported by Wani [21]. Similar results were also reported by Irshad et al. [22] while studying the soils of North Kashmir. The increased amount of water-soluble K which forms the part of available K) in lower belts is due to presence of more available K at this elevation. HNO_3 extractable -K ranged from 304-876 mg kg^{-1} with a mean value of 463 and 484 mg kg^{-1} for upper and lower belts respectively. The higher content of fixed -K in soils may be attributed to illitic clays in soils of Kashmir as already studied by Wani [23]. The value of exchangeable-K ranged from 21.55 to 134.5 mg kg $^{-1}$ with a mean value of 46.70 mg kg $^{-1}$ for upper belts and 49.30 mg kg $^{-1}$ for lower belts (Table 2). Irshad et al. [24] reported similar findings while studying various geochemical forms of potassium in soils of North Kashmir. Lower belts were having higher amount of exchangeable K which may be due to higher amount of organic matter which might have retained more K ions at exchange sites [25]. Non-exchangeable-K showed similar trend with a range of 318-556 mg kg $^{-1}$ in upper belts and 264-736 mg kg $^{-1}$with a mean value of 408.9mg kg $^{-1}$and 424.29 mg kg $^{-1}$ in upper and lower belts respectively. The amount of Lattice -K ranged from 10651 to 15193 mg kg $^{-1}$with a mean value of 12315 mg kg $^{-1}$for upper belts and 12200 for lower belts (Table 2). The decrease in amount of clay with a decrease in altitude may be due to lesser amount of clay present in lower belts [26]. Higher amount of lattice-K in higher altitude may also be due to mineralogical make up and degree of weathering. Bashir et al. [27] reported similar trend for lattice potassium while studying distribution of different forms of potassium in temperate regions of Kashmir. Talib and Verma [28] while studying Kashmir soils in a toposequence have also reported similar trend. Total K in soils ranged from 11022 to 16032 mg kg $^{-1}$with a mean value of 12778 mg kg $^{-1}$for upper belts and 12684 mg kg $^{-1}$ for lower belts (Table 2). The higher content in higher altitudes is due to presence of illite, mica and feldspars which are the potential potassium-bearing minerals reported by Mushtaq and Raj [29].The results are also in accordance with results obtained by Abdul et al. [30].

In order to assess the influence of soil properties on various forms of K, coefficients of correlation were worked out. Water-soluble K, available K, Exchangeable and non-exchangeable K showed a significant negative relationship with soil pH with value of coefficient “r” -0.823**, 0.695**, -0.676**and -0.644** respectively (Table 3). Khadka et al. [31] reported similar results while studying the relationship between available potassium and soil pH. Earlier Singh and Mishra [32] had obtained similar results while studying soils of Varanasi. Other forms of potassium had a positive but non-significant relationship with soil pH. All forms of potassium were non- significantly correlated to EC, while as positive correlation of CEC with all forms of potassium could be found with correlation coefficient having values 0.780** for water soluble K, 0.682** for available K, 0.591** for HNO_3 soluble- K, 0.667**for exchangeable K, 0.557* for non exchangeable K, 0.573** for lattice K and 0.532* for Total K (Table 3). Kundu et al. [33] reported similar results while studying potassium forms in soils of West Bengal. Likewise Bashir et al. [34] reported similar results and attributed it to property of colloidal fractions (clay and humus) to act as

Table 1. Particle size distribution and physico-chemical properties of soils in Brown Sarson growing soils of district Kupwara, Kashmir

	Location	Sand %	Silt %	Clay %	Textural class	pH (1:2.5)	EC (dSm)	CEC + Cmol(p)Kg^{-1}	OC (%)
	Chalipora	25.0	43.0	32.0	CL	6.4	0.11	17.19	1.51
	Badarhar	24.0	44.0	30.0	CL	5.7	0.15	19.90	2.21
	Khahipora	26.0	43.0	31.0	CL	5.4	0.13	19.23	2.29
	Nabadzabi	35.0	40.0	25.0	L	5.8	0.12	18.01	1.96
	Bahadurpore	34.0	38.0	28.0	L	6.7	0.16	17.01	1.03
	Badrkali	34.0	39.0	27.0	L	6.7	0.20	17.15	1.19
	Zachaldara	23.56	38.77	37.67	Cl	5.4	0.13	19.96	2.20
	Nagranahar	36.39	42.44	22.19	L	6.0	0.15	17.05	1.16
	Shatigam	37.00	39.80	23.20	L	6.3	0.14	17.96	1.07
	Ahgam	36.20	40.60	23.20	L	6.5	0.16	16.90	1.10
	Range	23.56- 37.0	38.0-44.0	22.19-37.67		5.4-6.7	0.11-0.20	16.90-19.96	1.03-2.29
	Mean	31.115	40.86	27.92	-	6.09	0.145	18.03	1.57
	Ujroo	22.00	46.00	32.00	CL	5.3	0.16	20.10	2.32
	Khano -Babgund	50.0	20.0	30.0	L	5.3	0.11	20.57	2.20
	Yunus	24.0	44.0	30.0	CL	5.7	0.20	20.22	2.26
	Hanwara	25.0	45.0	30.0	CL	6.3	0.14	18.29	1.87
	Kachri	28.0	40.4	31.6	CL	6	0.14	18.42	1.92
Lower Belts	Yaroo	27.0	42.0	31.0	CL	6.6	0.11	17.21	1.75
	Chotipora	36.0	37.00	27	L	6.8	0.19	17.76	2.01
	Langate	43.80	36.20	20.00	L	5.6	0.20	19.97	2.03
	Khoro	45.20	34.10	20	L	6.3	0.14	18.05	1.66
	Wadipora	44.29	38.96	16.75	L	6.2	0.14	18.00	1.67
	Range	22.0-50.0	20.0-46.0	16.75-32.0		5.3-6.8	0.11-0.20	17.21-20.57	1.66-2.32
	Mean	34.52	38.36	26.83	-	6.01	0.15	18.86	1.96
	Range	22-50	20-46	16.75-37.67		5.3-6.8	0.11-0.20	16.90-20.57	1.03-2.29
	Overall mean	32.82	39.6	27.38	-	6.05	0.149	18.45	1.77
	SE	1.88	1.24	1.15		0.11	0.006	0.28	0.10

Table 2. Different forms of Potassium in Brown Sarson soils in District Kupwara, Kashmir

Location		**Water soluble K (mg kg^{-1})**	**Available K (mg kg^{-1})**	**HNO_3 Soluble K (mg kg^{-1})**	**Ex. K (mg kg^{-1})**	**Non Ex K (mg kg^{-1})**	**Lattice K (mg kg^{-1})**	**Total K (mg kg^{-1})**	
Chalipora		5.5	34	352	28.5	318	12497	12849	
Badarhar		9	67.5	522	58.5	454.5	12939	13461	
Khahipora		11	70	626	59	556	13594	14220	
Upper Belts Nabadzabi		6.5	53.5	435	47	381.5	12555	12990	
Bahadurpore		6.5	38	376	31.5	338	11256	11632	
Badrkali		5.5	37	389	31.5	352	12382	12771	
Zachaldara		11	90	587	79	497	12952	13539	
Nagranahar		7	38	450	31	412	11816	12266	
Shatigam		5.5	48.5	406	43	357.5	11121	11527	
Ahgam		6	64.5	487	58.5	422.5	12039	12526	
Range		5.5 -11.0	34 - 90	352 - 626	23.5 – 79.0	318-556	11121-13594	11527-14220	
	Mean	7.35	54.10	463.0	46.70	408.9	12315	12778	
	Ujroo	13	103	839	90	736	15193	16032	
	KhanoBabgund	14.5	149	876	134.5	727	15069	15945	
	Yunus	8	63	380	55	317	10651	11031	
	Hanwara	6.5	47.5	462	41	414.5	11977	12439	
Lower Belts	Kachri	6.5	40	304	33.5	264	10718	11022	
	Yaroo	7.5	60.5	463	53	402.5	11939	12402	
	Chotipora	5.5	32.5	395	27	362.5	11705	12100	
	Langate	8	46	403	38	357	12551	12954	
	Khoro	5.5	27.05	325	21.55	297.95	10918	11243	
	Wadipora	5.5	30.5	395	25	364.5	11281	11676	
	Range	5.5-14.5	27.05-149	304-876	21.55-134.5	264-736	10651-15193	11022-16032	
	Mean	8.05	59.05	484.2	46.80	424.29	12200.2	12684.4	
	Overall Range	5.5-14.5	27.09-149	304-876	21.55-134.5	264-736	10651-15193	11022-16032	
Overall Mean		7.7	57.0	473.6	49.30	416.5 28.43	12257.65	12731	313.74
SE		0.60	6.58	34.38	5.73		282.02		

Ex. K = exchangeable K ; Non Ex K= Non exchangeable K

Table 3. Correlation between Soil Properties and Potassium Forms

	Water Soluble K	Av. K	HNO_3 Soluble K	Exch. K	Non- Exch. K	Lattice K	Total K
pH	-0.823	-0.695*	0.389	-0.676**	-0.644**	0.360	0.365
EC	-0.218	-0.285^{NS}	-0.268	-0.289	-0.258	-0.214	-0.220
CEC	0.780	0.682**	0.591*	0.667**	0.557*	0.573**	0.532*
OC	0.656	0.518*	0.483*	0.500	0.465*	0.511*	0.510
Clay	0.510	0.480*	0.389	0.473*	0.359	0.360	0.365

primary reservoirs of exchangeable potassium as these fractions are amenable for inducing CEC [35]. Significant positive correlation of organic carbon with water soluble K (r=0.656**), Available K (r=0.518*), HNO_3 soluble K (r=0.483*), non exchangeable-K (r=0.465*) and lattice K (r=0.511*) was reported (Table 3) and the result was in agreement with finding of Elbaalawy et al. [36]. Significant correlation with organic carbon content in soils may be explained by the increasing exchange surfaces available for the positively charged K ions. It was reported in many studies that potassium forms have a positive correlation with clay content. Some of the researches substantiating the statement are Kaskar et al. [37], Abu-taleb et al. [38] same was reported in an investigation where clay content had a positive correlation with water soluble K (r= 0.510*), available K (r=0.480*) and exchangeable K (r=0.473*).

4. CONCLUSION

It was concluded from the study that lower belts of the region had higher content of all forms of potassium as compared to higher belts. There was a wide variability in potassium forms between higher and lower altitude that was attributed to variation in physico-chemical properties of soil in these areas and mineralogy. All forms of K were positively correlated with CEC, OC and clay content. However there was a negative correlation between soil pH and Potassium form. It is therefore necessary to take into consideration all physico- chemical properties of the site before formulating a fertilizer recommendation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mengel K. Potassium. In Barker A V and Pilbeam D J(eds), Tailor and Francis, New York; 2007.
2. Krauss, A. Balanced Fertilization in Contemporary Plant Production. The Role of Potassium. Regonal IPI workshop. Lithuania;2003.
3. Barber SA. Potassium availability at the soil-root interface and factors influencing potassium uptake. In: Potassium in Agriculture (Ed. R.D. Munson) ASA, Madiso. 1985; 309.
4. Ngwe K, Kheoruenromne I, Suddhiprakarn A. Potassium status and physicochemical and mineralogical properties of lowland vertisols in a rice-based cropping system under tropical savanna climate. Kasetsart Journal Natural Science. 2012; 46:522-37.
5. Wani MA. Dynamics of potassium release in some soils of Kashmir. Ph.D. thesis, Submitted to Sher-e-Kashmir University of Agricultural Sciences &Technology of Kashmir, Shalimar, Srinagar, India. 2005; 171-207.
6. Sarkar GK, Debnath A, Chattopadhyay AP, Sanyal SK. Depletion of soil potassium under exhaustive cropping in Inceptisol and Alfisols. Communications in Soil Science and Plant Analysis.2014; 45: 61–72.
7. Tiwari SP, Joshi OP, Vyas AK, Billore SD. Potassium nutrition in yield and quality improvement of soyabean. Proceedings of the International Symposium on Potassium for Sustainable Crop Production. 2002; 307- 321.
8. Saini J, Grewal KS. Vertical distribution of different forms of potassium and their relationship with different soil properties in some Haryana soil under different crop rotation. Advances in Plants & Agriculture Research. 2014; 1:1-10.
9. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi;1973.
10. Walkley A, Black IA. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science.1934; 37(1): 29-37.

11. Piper CS. Soil and Plant Analysis. Hans Publisher, Bombay; 1966.
12. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi;1973.
13. Dhillon SK, Sidhu PS, Dhillon KS, Sharma YP. Distribution of various potassium forms in some benchmark soils of north west India .Journal of Potassium Research.1985;1: 154- 165.
14. Pratt PF. Methods of Soil Analysis. Part II, In Chemical and Microbiological Properties. America, Madison, Wisconsin, USA; 1982.
15. Irshad I, Chesti MH, Mir S, Mansoor M, Kirmani NA, Sofi JA,Qadri TN. Distribution of different forms of potassium in soils of district Ganderbal of Kashmir region. Journal of the Indian Society of Soil Science. 2020; 68(2):194-200.
16. Alaie TA. Soil Fertility Assessment of Maize Growing Soils of Handwara, District Kupwara of Northern Kashmir.Chemical Science Review and Letters. 2021;10:343-349.
17. Wani MA. Kinetics of non-exchangeable potassium release from some soils and their separates of lesser Himalayas of India. Journal of the Indian Society of Soil Science.2009;57:137-144.
18. Baba ZA, Aziz MA, Sheikh TA, Sheikh FA, Bhat ZA, Sana K, Basharat H.Studies on soil health and plant growth promoting potential of Rhizobium isolates. Emirates Journal of Food and Agriculture**.** 2015; 27:423-429.
19. Ahad T, Kanth TA, Nabi, S. Soil bulk density as related to texture, organic matter content and porosity in kandi soils of district Kupwara (Kashmir Valley), India.Geography. 2015; 4:198-200.
20. Wani MA. Kinetics of non-exchangeable potassium release from some soils and their separates of lesser Himalayas of India. Journal of the Indian Society of Soil Science.2009; 57:137-144.
21. Wani MA. Dynamics of potassium release in some soils of Kashmir. Ph.D. thesis, Submitted to Sher-e-Kashmir University of Agricultural Sciences &Technology of Kashmir, Shalimar, Srinagar, India. 2005; 171-207.
22. Irshad I, Chesti MH. Mir S, Mansoor M, Kirmani NA, Sofi JA,Qadri TN. Distribution of different forms of potassium in soils of district Ganderbal of Kashmir region. Journal of the Indian Society of Soil Science. 2020; 68(2):194-200.
23. Wani MA. Kinetics of non-exchangeable potassium release from some soils and their separates of lesser Himalayas of India.JournaloftheIndianSocietyofSoilScience.2009; 57:137-144.
24. Irshad I, Chesti MH. Mir S, Mansoor M, Kirmani NA, Sofi JA,Qadri TN. Distribution of different forms of potassium in soils of district Ganderbal of Kashmir region. Journal of the Indian Society of Soil Science. 2020; 68(2):194-200.
25. Jagadeesh, B.R. Dynamics of potassium in soils of selected agro-climatic zones of Karnataka. Ph. D. Thesis, University of Agricultural Sciences, Bangalore, Karnataka (India).2003.
26. Parker DR, Hendricks GJ, Sparks D.L. Potassium in Atlantic Coastal Plain Soils, I. Soil characterization and distribution of potassium. AmericanJournal of Society Soil Science.1989; 53**:**392-396.
27. BashirU, AliT, Qureshi F. Distribution of different forms of potassium under temperature conditions of Kashmir. International Journal of Agriculture, Environment and Biotechnology. 2016; 9(2):213.
28. Talib AR, Verma SD. Relationship between different forms of potassium and particlesize in benchmark soils of Kashmir. Indian Journal of Agricultural Sciences. 1990; 60:643-644.
29. Mushtaq AW, Raj K. Distribution of potassium and clay minerals assemblage in some paddy soils of Lesser Himalayas. Agropedology.2008; 18:98-105.
30. Abdul W, Mehreen G, Muhammad S. Potassium dynamics in three alluvial soils differing in clay contents. Journal of Food and Agriculture.2013; 25:39-44.
31. Khadka D, Lamichhane S, Thapa B. Assessment of relationship between soil pH and macronutrients, Western Nepal. Journal of Chemical, Biological and Physical Sciences2016; 6:303.
32. Singh RP, Mishra SK. Available macronutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (UP) in relation to soil characteristics. Indian Journal of Scientific Research. 2012; 3:97-100.
33. Kundu MC, Hazra GC, Biswas PK, Mondal S, Ghosh GK. Forms and distribution of potassium in some soils of

Hooghly district of West Bengal. Crucible. 2014; 2:4.
34. Bashir U, Ali T, Qureshi F. Distribution of different forms of potassium under temperature conditions of Kashmir. International Journal of Agriculture, Environment and Biotechnology. 2016; 9(2):213.
35. Talib AR, Verma SD. Relationship between different forms of potassium and particlesizeinbenchmarksoilsofKashmir.IndianJournalofAgriculturalSciences.1990;60: 6 43-644.
36. Elbaalawy M, Benbi DK, Benipal DS. Potassium forms in relation to clay mineralogy and other soil properties in different agro-ecological sub-regions of northern India. Agriculture Research Journal.2016; 53:200-206.
37. Kaskar DR, Salvi VG, Mayekar BS, Dabke DJ. Forms of potassium, their interrelationship and relationships with other soil properties of Inceptisols of west coast of Maharashtra. Journal of Potassium Research. 2001; 17:23-27.
38. AbuTaleb, MondalS, Siddiqui MZ. Distribution of different forms of potassium in lateritic soils of birbhum, West Bengal Programme on Agriculture. 2010;10:134-37.

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