Biological Forum – An International Journal **15(7): 419-423(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Dynamics of Potassium Fractions in Surface and Subsurface Soil under Different Land use Systems in Alnavar Taluk, Dharwad District, Karnataka

Ramesh[1*], Vijay Kumar C.[2] and Jakir Hussain K.N.[3]

[1]Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, UAS, Raichur (Karnataka), India.
[2]Scientist (Soil Science) ICAR- Krishi Vigyan Kendra, UAS, Dharwad (Karnataka), India.
[3]Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, UAS, Dharwad (Karnataka), India.

(Corresponding author: Ramesh)*
(Received: 06 May 2023; Revised: 05 June 2023; Accepted: 17 June 2023; Published: 15 July 2023)
(Published by Research Trend)

ABSTRACT: A field survey and laboratory investigation were conducted to study the dynamics of potassium fractions in surface and subsurface soils under different land use systems in Alnavar taluk, Dharwad district. A total of 120 composite soil samples were collected, comprising 60 samples from the surface layer (0–20 cm) and 60 from the subsurface layer (20–40 cm), which were analyzed for various forms of potassium. The results indicated that the sugarcane-based land use system recorded the highest potassium fraction content, with water-soluble K (WS-K) ranging from 3.01 to 5.11 mg kg^{-1}, exchangeable K from 105.09 to 182.09 mg kg^{-1}, non-exchangeable K from 214.95 to 452.15 mg kg^{-1}, lattice K from 8685 to 13160 mg kg^{-1}, and total K from 9181 to 13750 mg kg^{-1}. This high potassium content in the sugarcane system can be attributed to the frequent application of potassic fertilizers and the incorporation of organic manures and residues, which enhance soil fertility. In contrast, other land use systems showed comparatively lower potassium fraction contents. The study underscores the significance of land use systems in influencing potassium dynamics in soils, highlighting the need for sustainable nutrient management practices to optimize soil fertility and improve agricultural productivity. These findings contribute to the knowledge of potassium dynamics in diverse agricultural systems and can guide farmers and land managers in implementing strategies to maintain and enhance soil nutrient levels.

Keywords: Potassium, Fractions, Alnavar, Different Land Use Systems, Lattice K, Total K.

INTRODUCTION

Potassium (K) is one of the essential macronutrients required for plant growth, playing a crucial role in various physiological processes such as enzyme activation, protein synthesis, and photosynthesis. It is involved in maintaining osmotic balance and water regulation in plants, thereby enhancing crop resilience under abiotic stress conditions. Despite its importance, the availability of K in soils is highly variable due to its complex nature and distribution among various forms. In soils, K exists in four distinct fractions: water-soluble, exchangeable, non-exchangeable, and lattice K, which differ in their accessibility and contribution to the overall K nutrition of plants (Brouder, 2011). The proportion of these K fractions is influenced by soil properties, mineralogy, management practices, and land use systems, making it essential to understand their dynamics for sustainable nutrient management (Balík *et al.*, 2020; Bhat *et al.*, 2017; Murali and Tayal 2018)

Land use changes significantly affect soil properties, nutrient availability, and K distribution patterns. Different cropping systems and management practices alter the balance between K inputs and outputs, influencing the transformation and redistribution of K fractions in soils. Intensive cropping systems, such as those under sugarcane and maize, often require high K inputs, which can modify the proportions of water-soluble and exchangeable K. On the other hand, traditional systems like paddy or forest land use tend to have lower K availability due to the depletion of labile K forms or minimal external K additions. As a result, the study of K dynamics under varying land use systems provides crucial insights into soil fertility and the long-term sustainability of agricultural practices (Thenabadu, 1973, Hebsur, 1997; Anil *et al.*, 2009).

Alnavar taluk in Dharwad district, Karnataka, is characterized by diverse land use patterns, including agricultural systems such as maize, paddy, and sugarcane, along with natural forest ecosystems. The variations in soil management and cropping intensity across these systems present an opportunity to investigate how land use influences K dynamics in surface and subsurface soils. Understanding the distribution of K fractions in this region is vital for devising site-specific nutrient management strategies that can enhance crop productivity and maintain soil health.

The present study aims to evaluate the dynamics of various K fractions—water-soluble, exchangeable, non-exchangeable, and lattice K—under different land use systems in Alnavar taluk. By comparing surface and subsurface soils, the study seeks to identify the impact of different land use practices on K availability and its long-term sustainability. This research will contribute to a better understanding of K management and guide appropriate nutrient management practices for different land use systems to optimize soil fertility and support sustainable agricultural development in the region.

MATERIAL AND METHODS

A field survey and laboratory investigation was carried out to study the dynamics of potassium fractions in surface and subsurface soil under different land use systems in Alnavar taluk, Dharwad district, Karnataka at the College of Agriculture, Dharwad during the year 2020-21.

In each land use system, 15 locations were selected from sugarcane, paddy, maize and forest ecosystem, respectively.

A total of 120 composite soil samples were collected in which 60 composite soil samples from surface layer (0-20cm depth) and 60 composite soil samples from sub-surface layer (20-40cm depth). Soil samples were collected from different land use systems to study different fractions of potassium *viz*., water soluble-K, exchangeable-K, Non-exchangeable-K, lattice-K and total-K.

RESULTS AND DISCUSSION

The contents of various potassium (K) fractions—namely water-soluble K, exchangeable K, non-exchangeable K, lattice K, and total K—varied significantly across different land use systems and soil depths (surface and subsurface) presented in table 1, 2, 3 4. The sugarcane-based land use system exhibited the highest levels of these K fractions compared to maize, paddy, and forest-based systems. The mean values of water-soluble K were recorded as 4.04 mg kg^{-1} in surface and 3.67 mg kg^{-1} in sub-surface soil, while exchangeable K content was 145.98 mg kg^{-1} in surface and 124.80 mg kg^{-1} in sub-surface soil. The lattice-K content was 11,957 mg kg^{-1} and 12,513 mg kg^{-1} in surface and sub-surface soils, respectively, and total K content ranged from 11,817 mg kg^{-1} to 12,513 mg kg^{-1} in surface and sub-surface soil, respectively. These high levels of K fractions in the sugarcane system can be attributed to frequent potassic fertilizer applications, organic manures, and residue incorporation, as well as the intensive cultivation practices. This observation aligns with findings by Hebsur (1997), who highlighted that sugarcane systems often maintain elevated levels of water-soluble and exchangeable K due to consistent fertilization and management practices.

Potassium Fractions in Different Land Use Systems:

1. Water Soluble and Exchangeable K Fractions: The sugarcane-based system showed the highest levels of both water-soluble and exchangeable K in surface soil layers. The increased water-soluble K can be explained by the regular addition of K fertilizers, coupled with the mineralization of organic residues and the incorporation of sugarcane trash. These factors likely contributed to an elevated pool of readily available K for plant uptake. Additionally, the high exchangeable K in surface soil is linked to higher crop residues and humus content, which enhance soil aggregation and K retention. Variations in clay content and intensive K management practices further explain the substantial exchangeable K levels in surface soils, as noted by Hebsur (1997); Anil *et al*. (2009).

2. Non-Exchangeable K Fraction: Non-exchangeable K was generally higher in subsurface soils across all land use systems. This trend can be attributed to the increased presence of clay and silt particles in deeper layers, which can hold more K within their mineral structure. The lower surface content is likely due to greater biological activity and root uptake, resulting in the depletion of this fraction in the surface horizons. These findings suggest that non-exchangeable K serves as a long-term reserve that can potentially be released to satisfy crop requirements under intensive cropping systems. Similar results were reported by Kaptan *et al.* (2001); Hebsur and Gali (2011); Jagadeesh (2003).

3. Lattice K and Total K Fractions: Lattice K and total K fractions were highest under the sugarcane-based system, both in surface and sub-surface soils. In fact, lattice K made up the majority of the total K content in all systems. The high lattice K content in sub-surface soils of all land use systems suggests that these soils are derived from potassium-bearing minerals, such as 2:1 type clay minerals, which contribute to substantial lattice K reserves. The higher total K in sub-surface soils across all systems indicates the presence of parent materials rich in K-bearing minerals, supporting the long-term sustainability of these soils in terms of K availability (Ranganathan and Sathyanarayana 1980).

Comparison of Potassium Fractions in Surface and Subsurface Soils:

The study revealed that water-soluble and exchangeable K fractions were consistently higher in surface soils compared to sub-surface soils across all land use systems. This pattern can be attributed to surface applications of K fertilizers and the accumulation of organic residues in the topsoil, which enhance the availability of these readily exchangeable forms. Conversely, non-exchangeable K, lattice K, and total K fractions were generally higher in sub-surface soils. The higher non-exchangeable and lattice K in sub-surface layers might be due to the gradual release of K from primary and secondary minerals in deeper soil layers, these findings corroborate the findings of Adhikari and Ghosh (1991) (Fig. 1).

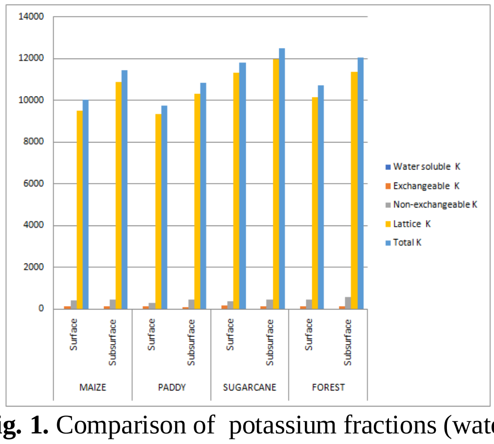

Fig. 1. Comparison of potassium fractions (water-soluble K, exchangeable K, non-exchangeable K, lattice K) in surface and subsurface soil under each land use system.

Effect of Land Use on Potassium Fractions:

Sugarcane System: The sugarcane-based system recorded the highest values for all K fractions, which can be attributed to intensive K management practices, such as the repeated addition of potassic fertilizers and the incorporation of organic residues. Additionally, deep root systems of sugarcane may have contributed to K cycling and accumulation in both surface and sub-surface layers (Table 3).

Paddy and Maize Systems: The paddy-based system recorded the lowest contents of all K fractions, indicating reduced K availability. This could be due to leaching losses and the depletion of exchangeable and non-exchangeable K under continuous rice cultivation. Similarly, maize-based systems showed relatively low K levels, which might be attributed to less K input and a limited capacity of soils to retain K in the absence of intensive fertilization (Table 1 and 2).

Forest System: Forest soils exhibited relatively high levels of total K and lattice K, particularly in subsurface layers. This can be linked to the natural recycling of nutrients through leaf litter decomposition and minimal nutrient removal. The accumulation of lattice K indicates the stability of K-bearing minerals in these undisturbed soils (Table 4). The results are in comparison with those of research findings reported by Hebsur and Gali (2011); Jagmohan and Grewal (2014).

Table 1: Status of different forms (mg kg^{-1}) of potassium under maize-based land use system.

Sr. No.	Water soluble K		Exchangeable K		Non-exchangeable K		Lattice K		Total K	
	(Depth)									
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	3.02	3.16	158.78	156.74	499.20	526.30	11149	12743	11810	13430
2.	3.47	3.30	89.33	67.70	364.40	413.60	9962	11985	10420	12470
3.	3.46	3.02	161.19	128.28	511.23	541.50	7754	10027	8432	10700
4.	3.94	3.24	112.66	110.16	469.80	370.40	8653	10776	9241	11260
5.	3.98	3.04	135.62	136.06	446.48	490.50	8013	9670	8601	10300
6.	3.47	3.28	134.33	126.82	495.81	544.70	11476	12495	12110	13170
7.	3.39	2.88	93.01	80.42	444.43	505.90	10279	11405	10820	11995
8.	3.62	1.84	160.23	99.86	417.80	392.30	9298	12336	9880	12830
9.	4.14	3.66	135.16	102.24	405.30	458.90	11195	12635	11740	13200
10.	2.94	2.85	110.46	92.45	458.20	480.50	9928	10109	10500	10685
11.	3.59	3.45	153.56	128.55	355.10	462.60	8797	9400	9313	9995
12.	3.43	3.22	126.37	122.88	407.85	470.10	7932	8663	8471	9260
13.	2.96	2.50	124.24	96.40	380.80	437.70	11172	11918	11680	12455
14.	3.36	3.10	107.24	96.50	329.40	414.00	8650	9241	9095	9755
15.	3.26	3.09	100.14	74.71	293.60	367.80	8153	9693	8555	10139
Range	**2.94-4.14**	**1.84-3.66**	**89.33-161.19**	**67.7-156.74**	**293.6-511.23**	**367.8-544.70**	**7754-11476**	**8663-12743**	**8432-12110**	**9260-13430**
Mean	**3.47**	**3.04**	**126.82**	**107.98**	**418.63**	**458.45**	**9494**	**10873**	**10044**	**11442**
S.Em±	**0.09**	**0.11**	**6.31**	**6.43**	**16.75**	**15.06**	**343.66**	**364.16**	**347.58**	**366.47**
C.V(%)	**10.26**	**14.07**	**19.26**	**23.06**	**15.50**	**12.72**	**14.02**	**12.97**	**13.40**	**12.40**

Table 2: Status of different forms (mg kg^{-1}) of potassium under paddy-based land use system.

Sr. No.	Water soluble K		Exchangeable K		Non-exchangeable K		Lattice K		Total K	
	(Depth)									
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	2.36	2.03	108.04	90.67	335.05	465.42	8164	10001	8615	10560
2.	3.01	2.28	91.49	58.92	293.78	449.02	8781	10259	9172	10770
3.	2.92	2.89	134.78	103.91	177.80	414.70	9864	10798	10180	11320
4.	3.04	3.15	112.06	78.65	355.92	455.28	8968	11302	9441	11840
5.	3.60	3.54	105.50	91.56	211.17	438.40	9529	10766	9852	11320
6.	1.85	1.90	109.65	81.30	192.05	392.83	10256	10293	10560	10770
7.	1.38	1.25	134.52	112.55	285.86	410.25	9048	10825	9473	11350
8.	1.26	1.09	107.74	89.61	242.99	377.71	7828	8471	8182	8942
9.	1.63	1.86	139.77	118.94	185.40	409.03	10413	10670	10740	11230
10.	3.57	3.65	122.63	85.55	302.34	436.37	7971	9014	8405	9541
11.	1.75	1.42	128.55	94.48	188.26	498.90	10741	10565	11060	11160
12.	1.16	1.22	112.44	108.68	341.32	439.08	9765	10971	10220	11520
13.	1.66	1.09	104.94	75.71	267.27	451.06	8056	8902	8436	9432
14.	1.16	1.11	99.54	84.64	296.42	511.22	10942	10873	11340	11470
15.	3.08	2.68	149.92	101.32	298.97	359.14	10048	11206	10500	11670
Range	**1.16-3.60**	**1.09-3.65**	**91.49-149.92**	**58.92-118.94**	**177.8-355.92**	**359.14-511.22**	**7828-10942**	**8471-11302**	**8182-11340**	**8942-11840**
Mean	**2.23**	**2.08**	**117.44**	**91.77**	**264.97**	**433.89**	**9358**	**10328**	**9745**	**10859**
S.Em±	**0.23**	**0.24**	**4.30**	**4.03**	**15.79**	**10.74**	**269.36**	**224.51**	**264.10**	**227.60**
C.V(%)	**40.07**	**43.91**	**14.19**	**17.02**	**23.07**	**9.58**	**11.15**	**8.42**	**10.50**	**8.12**

Table 3: Status of different forms of potassium (mg kg^{-1}) under sugarcane-based land use system.

Sr. No.	Water soluble K		Exchangeable K		Non-exchangeable K		Lattice K		Total K	
	(depth)									
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	5.11	4.95	182.09	173.05	432.40	566.20	12580	13105	13200	13850
2.	4.94	4.56	151.36	136.14	370.90	404.90	11422	12054	11950	12600
3.	4.25	4.35	132.65	117.35	452.15	528.70	13160	14749	13750	15400
4.	3.59	3.05	119.91	104.35	438.23	562.60	8738	10280	9302	10950
5.	3.22	2.98	170.78	158.22	426.00	466.20	11530	11832	12130	12460
6.	3.70	3.20	141.90	116.10	261.30	250.50	11933	12140	12340	12510
7.	4.29	3.96	177.51	161.54	376.48	397.18	11221	11477	11780	12040
8.	3.13	2.98	171.67	146.52	268.17	339.28	11047	11351	11490	11840
9.	4.84	3.05	151.36	126.85	371.15	386.90	10742	11053	11270	11570
10.	3.01	2.90	146.79	116.00	293.01	381.30	12667	12989	13110	13490
11.	3.55	3.01	146.65	137.19	343.98	518.80	8685	8831	9181	9490
12.	3.90	3.75	118.00	96.75	398.47	498.10	12179	12441	12700	13040
13.	3.83	3.60	131.17	102.30	326.36	408.90	11368	12445	11830	12960
14.	4.36	4.15	142.74	124.75	214.95	327.70	11627	12663	11990	13120
15.	4.81	4.50	105.09	88.70	295.97	340.00	10834	11946	11240	12380
Range	**3.01-5.11**	**2.9-4.95**	**105.09-182.09**	**88.7-173.05**	**214.95-452.15**	**250.5-566.2**	**8685-13160**	**8831-14749**	**9181-13750**	**9490-15400**
Mean	**4.04**	**3.67**	**145.98**	**127.05**	**351.30**	**425.15**	**11316**	**11957**	**11817**	**12513**
S.Em±	**0.18**	**0.18**	**5.85**	**6.44**	**18.80**	**24.37**	**325.99**	**346.50**	**327.58**	**345.71**
C.V(%)	**16.99**	**19.12**	**15.53**	**19.62**	**20.73**	**22.20**	**11.16**	**11.22**	**10.74**	**10.70**

Table 4: Status of different forms of potassium (mg kg^{-1}) under forest-based land use system.

Sr. No.	Water soluble K		Exchangeable K		Non-exchangeable K		Lattice K		Total K	
	(depth)									
	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
1.	4.11	3.74	120.61	108.93	478.48	580.53	10196	11156	10810	11850
2.	2.28	0.81	114.84	98.06	362.88	480.93	9170	10650	9650	11230
3.	2.79	1.30	99.48	79.87	480.13	618.63	9217	10790	9805	11490
4.	2.42	0.65	148.60	134.75	453.58	508.40	10725	11886	11330	12530
5.	3.67	1.03	107.60	119.77	492.13	509.20	10546	11740	11150	12370
6.	2.94	1.60	136.38	115.37	577.28	671.63	11233	12041	11950	12830
7.	3.43	1.83	107.59	79.44	418.18	521.93	11630	12886	12160	13490
8.	4.09	2.96	144.98	172.54	510.33	584.90	10850	12199	11510	12960
9.	1.14	0.38	139.53	148.12	415.93	525.10	8943	10166	9510	10840
10.	3.82	1.85	95.65	125.05	418.13	547.50	9732	11195	10250	11870
11.	1.70	1.31	134.57	123.46	439.93	585.03	12523	13220	13100	13930
12.	1.48	0.93	116.24	84.14	385.48	438.33	9146	10906	9650	11430
13.	1.30	0.83	121.17	145.97	336.13	445.20	8191	9368	8650	9960
14.	3.75	2.79	140.72	161.61	559.33	653.40	12306	13192	13010	14010
15.	2.40	2.02	144.07	120.05	510.73	637.33	7792	9310	8450	10070
Range	**1.14-4.11**	**0.38-3.74**	**95.65-148.60**	**79.44-172.54**	**336.13-577.28**	**438.33-671.63**	**7792-12523**	**9310-13220**	**8450-13100**	**9960-14010**
Mean	**2.75**	**1.60**	**124.80**	**121.14**	**455.91**	**553.87**	**10147**	**11380**	**10732**	**12057**
S.Em±	**0.27**	**0.25**	**4.54**	**7.35**	**17.79**	**18.77**	**368.34**	**319.43**	**377.53**	**326.70**
C.V(%)	**37.57**	**59.44**	**14.09**	**23.51**	**15.11**	**13.13**	**14.06**	**10.87**	**13.62**	**10.49**

CONCLUSIONS

Among the different K fractions in the surface and sub-surface soils of different land use systems, the WS-K was found lowest and is in the range of 1.60 to 4.04 mg kg^{-1}, followed by Ex- K (91.77 to 195.98 mg kg^{-1}), Non-Ex.-K (197.38 to 773.77 mg kg^{-1}), lattice K (1.89 to 2.40 %) and total K (1.93 to 2.50 %) and among the different land use systems sugarcane land use system recorded higher potassium fractions content as compared to other land use systems and the available-K, WS- K and exchangeable-K fraction were recorded higher in surface soil and lower in sub-surface soil, whereas non-exchangeable-K, lattice K and total –K were recorded higher in subsurface soil in all the land use systems.

FUTURE SCOPE

The findings of this study highlight the need for further research to explore the dynamics of potassium fractions under various cropping systems and long-term fertilization strategies. Future studies could focus on the impact of integrated nutrient management practices, crop rotation, and organic amendments on potassium availability in soils. Additionally, examining the interactions between potassium fractions and other soil nutrients could provide valuable insights into optimizing nutrient management for sustainable crop production. Expanding this research to different agro-climatic regions would help validate these results and guide region-specific soil fertility recommendations.

Acknowledgement. The authors express their sincere gratitude to the University of Agricultural Sciences, Dharwad for providing the necessary facilities and support to conduct this research. The authors are also grateful to all the farmers and local communities in Alnavar taluk for their cooperation and support during the soil sampling process. Finally, the corresponding author acknowledges the encouragement and guidance provided by the faculty members and colleagues of the Department of Soil Science and Agricultural Chemistry throughout the study.
Conflict of Interest. None.

REFERENCES

Adhikari, M. and Ghosh, T. K. (1991). Potassium reserves and quantity/intensity relationships of different soils of West Bengal. *Journal of Potash Research, 1*, 161-169.

Anil, S., Jalali, V. K., Arya, V. M., and Pradeep, R. (2009). Distribution of various forms of potassium in soils representing intermediate zone of Jammu region. *Journal of Indian Society of Soil Science, 57*(2), 205-207.

Balík, J., Kulhanek, M., Cerný, J., Sedlar, O., and Suran, P. (2020). Potassium fractions in soil and simple K balance in long-term fertilising experiments. *Soil and Water Research*, *15*(4), 211-219.

Bhat, S., Reddy, B. P. S., and Kumar, N. V. (2017). Evaluation of silkworm hybrids through exploitation of hybrid vigour. *International Journal of Sericulture and Technology*, *6*(1), 45-49.

Brouder, S. M. (2011). Potassium cycling in agricultural systems. In Hatfield, J. L., and Sauer, T. J. (Eds.), *Soil Management: Building a Stable Base for Agriculture*. Madison, American Society of Agronomy and Soil Science Society of America, pp. 79-102

Hebsur, N. S. (1997). Studies on chemistry of potassium in sugarcane soils of North Karnataka. Ph. D. Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India).

Hebsur, N. S. and Gali, S. K. (2011). Potassium dynamics in soils under different cropping systems of Karnataka. Soil Science Research in North Karnataka, *76th Annual Convention of Indian Society of Soil Science*, 85-89.

Jagadeesh, B. R. (2003). Dynamics of potassium in soils of selected agro-climatic zones of Karnataka. Ph.D. Thesis, University of Agricultural Sciences, Bangalore, Karnataka (India).

Jagmohan, S. and Grewal, K. S. (2014). Vertical distribution of different forms of potassium and their relationship with different soil properties in some Haryana soil under different crop rotation. *Advances in Plant and Agricultural Research, 1*(2), 1-5.

Kaptan, S., Malik, R. V. S., and Vinay, S. (2001). Distribution of forms of potassium in Alluvial soils. *Journal of Potash Research, 17*, 116-118.

Murali, K. S., and Tayal, P. (2018). Development of new silkworm hybrids for improving qualitative and quantitative traits. *Journal of Applied Sericulture*, *9*(2), 112-118.

Ranganathan, A. and Satyanarayana, T. (1980). Studies on potassium status of soils of Karnataka. *Journal of Indian Society of Soil Science, 28*(2), 148-153.

Thenabadu, M. W. (1973). Response of rice to potassium fertilization in the wet zone of Ceylon. Potash Review, Subject 16, Suite 65, 1-8.

How to cite this article: Ramesh, Vijay Kumar C. and Jakir Hussain K.N. (2023). Dynamics of Potassium Fractions in Surface and Subsurface Soil under Different Land use Systems in Alnavar Taluk, Dharwad District, Karnataka. *Biological Forum – An International Journal, 15*(7): 419-423.