Original Research Article

Studies on potassium fractions in central and southern dry zones of coconut growing areas of Hassan district of Karnataka, India

ABSTRACT

The experiment was conducted in an order to get an insight about the potassium (K) fractions in central and southern dry zone of coconut growing areas of Hassan district, Karnataka during 2022-23. The soil samples from surface (0-30 cm) and sub-surface (30-60 cm) were collected from the soils of selected coconut gardens of central and southern dry zones of Hassan district for the study. Results revealed that the average water soluble K, hot water soluble K, exchangeable K, non-exchangeable K, lattice K and total K in surface soils of coconut gardens of central dry zone of Hassan district registered was 2.76, 9.25, 54.65, 555.35, 5896.00 and 6509.00 mg kg^{-1}, respectively. Whereas the above potassium fractions in sub-surface soil recorded were 2.67, 7.70, 47.36, 699.66, 7282.00 and 8032.00 mg kg^{-1}, respectively. The various forms of potassium in surface soils of southern dry zone revealed that water soluble K, hot water-soluble K, exchangeable K, non-exchangeable K, lattice K and total K was 2.87, 8.85, 53.51, 546.61, 5603.00 and 6206.00 mg kg^{-1}, respectively. Whereas the above potassium fractions in sub-surface soil recorded were 2.21, 7.20, 45.21, 709.20, 7431.00 and 8188.00 mg kg^{-1}, respectively. The trend of decrease in water soluble K and exchangeable K from surface to sub-surface layers was noticed in soils of central and southern dry zone whereas non-exchangeable K, lattice K and total K exhibited an increasing trend with depth. The contribution of each form of potassium to total potassium was in the order of water soluble < hot water-soluble K< exchangeable < non-exchangeable < lattice K. Knowledge of different forms of potassium in soil together with their distribution has greater relevance in assessing the long-term K supplying power of soil to coconut palm and is important in formulating a sound fertilizer program for a given set of soil.

Key words: Potassium fractions, Central dry zone, Southern dry zone, coconut

1. Introduction

“Potassium is the major nutrient and also a most abundant element in soil but the K content of the soil varies from place to place based on physico-chemical properties of soil. Potassium exist in soil in different forms *viz.,* water soluble K, exchangeable K, non-exchangeable K, mineral K, lattice K and total K and these forms are heterogeneously distributed in soils. Its amount in soil depends on the parent material, degree of weathering, K gains through manures and fertilizers and losses due to crop removal, erosion and leaching. Usually the amounts of non-exchangeable K and total K present in the soil are high compared to water soluble K and exchangeable K. The dynamics of potassium in soil depends on the magnitude of equilibrium among various forms and mainly governed by the physico-chemical properties of soil. The bulk of soil potassium (about 98% of total K) usually exists in unavailable form in primary (micas and feldspars) and secondary (illite group) clay minerals. The available K and exchangeable K in general are readily available to plants”. [20]

“The nature of the different forms of potassium equilibrium is variable and depends upon the soil type and nature of the clay minerals. The readily available K constitutes only 1 to 2 per cent of total K and exists in soil in two forms, *viz.,* solution K and exchangeable K adsorbed on soil colloidal surface (Brady and Weil, 2002). These forms remain in dynamic equilibrium with one another. The readily available K or water soluble K has been reported to be a dominant fraction in the initial stage while, exchangeable K and non-exchangeable K contribute more in the later stages of crop growth”. [20]

"According to increasing order of plant availability, soil K exists in four forms *i.e*. mineral K (5000-25000 mg kg^{-1}), non-exchangeable K (50-750 mg kg^{-1}), exchangeable K (40-600 mg kg^{-1}) and solution K (1-10 mg kg^{-1}). K cycling or transformations among the K forms in soils are dynamic. Soils that are rich in vermiculite and micas can have large amounts of non-exchangeable K, whereas, soils containing kaolinite, quartz and other siliceous minerals contain less available and exchangeable K" (Martin and Sparks, 1985).

"Coconut has unique feature among the plantation crops in that it flowers and fruits throughout the year. Hence, adequate water and nutrients should be maintained during the entire period. Potassium regulates the water economy of the plant and so is indispensable for the rational utilization of limited water supplies for the production of the highest possible yields. It enables the plant to withstand drought. Potash is known to help root development, enabling the palm to take up more nutrients from the soil. Application of balanced fertilizers consisting of potassium to the nursery seedlings improved the vigour and quality of seedlings. Since potash is particularly necessary for the formation of sugar, fat, and fibrous material, the coconut palm may be expected to have a high requirement of potash" (Nelliat, 1973).

While some scattered information on potassium forms is available, comprehensive information about the distribution of potassium in coconut growing soils under central and southern dry zone of Hassan district is lacking. This study has investigated distribution of different potassium forms and their distribution in coconut growing soils occurring in Central and Southern dry zone of Hassan district of Karnataka state.

2. Materials and Methods

2.1 Study area

Hassan district is situated in the Karnataka state between latitude of 12°33' and 13°33' N, longitude of 75°33' and 76°38' East with altitude of 943.05 m and rainfall of 718-1200 mm (Anon., 2021). Administratively the district is divided into eight taluks and comes under four agro-climatic zones namely, central dry zone, southern dry zone, southern transitional zone and hilly zone. Arasikere taluk comes under Central dry zone, Channarayapatna taluk comes under southern dry zone, Holenarsipur, Arkalgud, Alur and Belur comes under southern transitional zone where as Sakleshpur taluk comes under hilly zone. Hassan has the second largest coconut growing area in the State with land area of 66637 ha with production of 6204 MT. Among the eight taluks present in Hassan district, Arisekere taluk which comes under central dry zone and Channarayapatna taluk which comes under southern dry zone contributes maximum towards the coconut production in the district (almost 81 per cent) (Anon., 2020). Henceforth, the study area was selected under two agro climatic zones as shown in (Fig. 1).

2.2 Soil sampling and analysis

Fifty random sampling location was selected from both taluk (Arasikere and Channarayapatna) at surface (0-30 cm) and sub surface (30-60 cm) depths at three meters away from the bole of palm based on yield (low, medium and high) of coconut tree. One hundred soil samples, 50 each from surface and sub surface soils were collected from coconut gardens in each agro climatic zone. Details of soil samples collected from central dry zone (Arasikere taluk) and southern dry zone (Channarayapatna taluk) of coconut growing areas of Hassan district, Karnataka are given in Table 1. Different forms of potassium was estimated by various standard protocols.

2.2.1 Water soluble potassium

Water soluble potassium was determined in 1:5 soil-water suspension after shaking for two hours and allowing to stand for an additional 16 hours (Black, 1965). The potassium in the extract was determined by flame photometer.

2.2.2 Hot-water soluble potassium

Hot water-soluble potassium was extracted by near to boiling distilled water (Nash, 1971).

2.2.3 Exchangeable potassium

Exchangeable potassium was determined by extracting with N *N* NH_4OAc solution as outlined by Knudsen *et al.* (1982). “Ten grams of soil sample was shaken with 25 ml of N *N* NH_4OAc solution for ten minutes and then centrifuged. The clear supernatant liquid was decanted into 100 ml volumetric flask. Three more additional extractions were made in the same manner and the combined extract was diluted to volume with NH_4OAc. The K content in the extract was determined by flame photometer. The water soluble K was subtracted from NH_4OAc-K to get the exchangeable potassium content of the soil”. Knudsen et al. (1982)

2.2.4 Non-exchangeable potassium

The boiling 1*N* HNO_3 method as outlined by Knudsen *et al.* (1982) was followed for “determination of non-exchangeable K in soil. Two and half gram of finely ground soil was boiled gently with 25 ml of 1*N* HNO_3 for 10 minutes. The content was filtered and the filtrate was collected in a 100 ml volumetric flask. The soil was then washed four times with 15 ml portions of 0.1 *N* HNO_3. After making up volume and mixing, the potassium content in the extract was determined using flame photometer. The quantity of K obtained with the NH_4OAc extract was subtracted to get the non-exchangeable potassium content in the soil”.

2.2.5 Total potassium

Total potassium content was determined by digesting the samples with hydrofluoric acid in a closed vessel (Lim and Jackson, 1982). “200 mg of finely ground soil sample was transferred into 250 ml wide mouth polypropylene bottle. Two ml of aqua regia was added to disperse the samples. Later 10 ml hydrofluoric acid was added by means of plastic pipette and after capping the bottle the contents were shaken to dissolve the sample for a period of 8 hours. The white residue remaining after the treatment was dissolved in 100 ml of saturated H_3BO_3 solution. The contents were diluted and final volume was made to 250 ml and subsequently used for analysis of total potassium by flame photometer”. (Lim and Jackson, 1982)

2.2.6 Lattice potassium

The lattice potassium was computed as difference between total potassium and the sum of water soluble, hot water soluble, exchangeable and non-exchangeable K fractions.

3. Result and Discussion

3.1 Water soluble potassium

The water soluble potassium in coconut growing soils of central dry zone of Hassan district varied from 1.20 to 4.68 mg kg^{-1} with a mean of 2.76 mg kg^{-1} in surface soils. The sub-surface water soluble K content varied from 1.10 to 5.12 mg kg^{-1} with a mean of 2.67 mg kg^{-1}. The higher water soluble K at surface and sub-surface depth was obtained in Byrambudhi (4.68 and 5.12 mg kg^{-1}, respectively). Whereas, the lowest water soluble K in surface and sub-surface depth was recorded in G. Shankaranahalli (1.20 and 1.00 mg kg^{-1}, respectively). Water soluble potassium contributes 0.04 per cent to total K in surface soils and 0.03 per cent in sub-surface soils (Table 2, Fig. 2).

The water soluble K of southern dry zone soil ranged from 2.04 to 3.88 mg kg^{-1} in surface soil with a mean of 2.87 mg kg^{-1}. The water soluble potassium in sub-surface soil varied from 1.32 to 3.24 mg kg^{-1} with a mean of 2.21 mg kg^{-1}. The water soluble potassium in surface layer was lowest in Shravaneri (2.04 mg kg^{-1}) soil and highest in Gollarahosahalli (3.88 mg kg-^{1}) soil. The highest sub-surface water soluble K was recorded in Gowdgere (3.24 mg kg^{-1}) soil and lowest in Dasarigatta (1.32 mg kg^{-1}) soil, respectively. Water soluble potassium contributes 0.05 per cent to total K in surface soils and 0.03 per cent in sub-surface soils (Table 3, Fig. 2).

The mean water soluble potassium was more in surface soil than sub-surface soil which might be due to addition of water soluble potash fertilizers at surface zone (Divya *et al.,* 2016). The southern dry zone were high in mean water soluble potassium content in both surface and sub-surface soil compared to central dry zone soil. The lowest water soluble potassium in plantation land use soils due to continuous K uptake by the plantation trees without external fertilization seems to be depleting K from these soils. Similar finding was reported by Sharma *et al*. (2006).

Removal of water soluble potassium from soil solution is buffered by readily exchangeable forms, which in turn, replenished by soil potassium reserves that further depends on clay mineralogical composition of soils (Bangroo *et al*., 2014). Therefore, it could be said that a weak dynamic between the forms of potassium existed in plantation soil of central and southern dry zone of Hassan district and has resulted in low quantity of water soluble potassium. (Debnath *et al*. 2017).

3.2 Hot water soluble potassium

The hot water soluble potassium in selected central dry zone soils of coconut growing areas of Hassan district varied from 6.03 to 15.93 mg kg^{-1} with a mean of 9.25 mg kg^{-1} in surface depth. The sub-surface hot water soluble K content varied from 4.02 to 14.34 mg kg^{-1} with a mean of 7.70 mg kg^{-1}. The highest hot water soluble K of surface and sub-surface layer was obtained in Byrambudhi (15.93 & 14.34 mg kg^{-1}) soil. The lowest hot water soluble K in surface and sub-surface depth was obtained in G. Shankaranahalli (6.03 & 4.02 mg kg^{-1}), respectively (Table 2, Fig. 2).

The hot water soluble K in selected southern dry zone soils of coconut growing areas of Hassan district ranged from 4.29 to 15.24 mg kg^{-1} in surface with a mean of 8.85 mg kg^{-1}. The hot water soluble potassium in sub-surface layer varied from 4.83 to 12.93 mg kg^{-1} with a mean of 7.20 mg kg^{-1}. The hot water soluble potassium in surface layer was lowest in Doddmatthagatta (4.29 mg kg^{-1}) soil and highest in Gollarahosahalli (15.24 mg kg^{-1}) soil. The highest sub-surface hot water soluble K was recorded in Gowdgere (12.93 mg kg^{-1}) soil and lowest in Dasarigatta (4.83 mg kg^{-1}) soil (Table 3, Fig. 2).

The mean hot water soluble potassium was more in surface than that of sub-surface. The central dry zone soil of coconut growing areas of Hassan district were high in mean hot water soluble potassium content in both surface and sub-surface samples than that of southern dry zone soil.

3.3 Exchangeable potassium

The exchangeable-K represents the fraction which is adsorbed on the soil surface. The exchangeable potassium content of coconut growing soils of central dry zone of Hassan district ranged from 39.38 to 75.32 mg kg^{-1} in surface soil, whereas, in sub-surface soils it varied from 28.17 to 68.43 mg kg^{-1}. The highest was obtained in Byrambudhi (75.32 and 68.43 mg kg^{-1}) for surface and sub-surface depths, respectively. The lowest exchangeable-K was recorded in G. Shankaranahalli (39.38 mg kg^{-1}) in surface soil and J. C Pura (28.17 mg kg^{-1}, respectively) in sub-surface depths, respectively. The mean values of exchangeable K were 54.65 and 47.36 mg kg^{-1} in surface and sub-surface soil, respectively. Exchangeable potassium contributes 0.84 per cent to total K in surface soils and 0.59 per cent in sub-surface soils of coconut gardens of central dry zone (Table 2, Fig. 2).

The southern dry zone soil exchangeable potassium varied from 36.09 to 73.62 mg kg^{-1} in surface, 29.93 to 65.18 mg kg^{-1} in sub-surface soils, respectively. In surface depth, exchangeable potassium was recorded highest in Gollarahosahalli (73.62 mg kg^{-1}) soil and lowest in Shravaneri (36.09 mg kg^{-1}) soil. The highest exchangeable potassium in sub-surface soil was recorded in Gollarahosahalli (65.18 mg kg^{-1}) soil and lowest in Dasarigatta (29.93 mg kg^{-1}) soil. The mean content of exchangeable K was 53.51 and 45.21 mg kg^{-1} in surface and sub-surface soils, respectively. Exchangeable potassium contributes 0.86 per cent to total K in surface soils and 0.55 per cent in sub-surface soils of southern dry zone of Hassan district (Table 3, Fig. 2).

The mean exchangeable potassium was more in surface soils compared to sub-surface soils in both agro-climatic zones which might be due to relatively higher organic carbon content and cation exchange capacity of soils in the surface soil. It was mainly due to capillary action of K^+ ions from sub-surface to surface sites and decreased exchange sites and increased compactness at lower depth (Divya *et al.,* 2016). The central dry zone soil recorded more exchangeable K in surface soil than southern dry zone soil. Similar trend was observed in sub-surface soil also. The exchangeable potassium in surface soil was high because of K fertilization and application of manures enriched the exchangeable sites of clay-humus complex there by increased the exchangeable K content (Hebsur and Gali., 2011).

3.4 Non-exchangeable potassium

The perusal of the data revealed that non-exchangeable potassium in coconut growing soils of central dry zone ranged from 404.23 to 676.00 mg kg^{-1} in surface and 476.35 to 840.85 mg kg^{-1} in sub-surface layer. The lowest non-exchangeable potassium was obtained in G. Shankaranahalli (404.23 mg kg^{-1}) soil and likewise highest was obtained in Byrambudhi (676.00 mg kg^{-1}) soil for surface depth. Likewise, in sub-surface depths, the highest non-exchangeable potassium was recorded in G. Byrambudhi (840.85 mg kg^{-1}) soil and lowest in G. Shankaranahalli (476.35 mg kg^{-1}) soil, respectively. Non-exchangeable potassium contributes 8.53 per cent to total K in surface soils and 8.71 per cent in sub-surface soils of central dry zone of Hassan district (Table 2, Fig. 2).

The non-exchangeable potassium of southern dry zone soil in surface samples varied from 441.88 to 662.50 mg kg^{-1}, 602.35 to 824.90 mg kg^{-1} in sub-surface depths, respectively. The surface non-exchangeable potassium recorded lowest in Shravaneri (441.88 mg kg^{-1}) soil and highest in Gollarahosahalli (662.50 mg kg^{-1}) soil. The sub-surface non-exchangeable potassium recorded lowest in Dasarighatta (602.35 mg kg^{-1}) soil and highest in Gollarahosahalli (824.90 mg kg^{-1}) soil, respectively. Non-exchangeable potassium contributes 8.81 per cent to total K in surface soils and 8.66 per cent in sub-surface soils of southern dry zone of Hassan district (Table 3, Fig. 2).

The average non-exchangeable potassium in surface soils of central dry zone recorded 555.35 mg kg^{-1} and that of sub-surface layer recorded 699.66 mg kg^{-1}. The average non-exchangeable potassium of surface layer in southern dry zone soil recorded 546.61 mg kg^{-1} and that of corresponding sub-surface recorded 709.20 mg kg^{-1}. The surface mean non-exchangeable potassium was recorded highest in central dry zone soil than that of southern dry zone soil, whereas sub-surface mean non-exchangeable potassium was *vice-versa*. Conversion of exchangeable and water soluble potassium into non-exchangeable potassium is a slow process but this equilibrium plays an important role in potassium nutrition of plants (Kundu *et al*., 2014).

3.5 Lattice potassium

The lattice potassium contents of coconut growing soils of central dry zone ranged from 3993 to 7744 mg kg^{-1} in surface soils, whereas, in sub-surface soils varied from 5085 to 9398 mg kg^{-1}, respectively. The highest lattice potassium was obtained in Byrambudhi (7744 and 9398 mg kg^{-1}, respectively) for surface and sub-surface depths, respectively. At both the depths, the lowest lattice potassium was recorded in G. Shankaranahalli (3993 and 5085 mg kg^{-1}, respectively). The mean values of lattice K were 5896 and 7282 mg kg^{-1} in surface and sub-surface soil, respectively. Lattice potassium contributes 90.59 per cent to total K in surface soils and 90.67 per cent in sub-surface soils of coconut gardens of central dry zone of Hassan district (Table 2, Fig. 2).

The southern dry zone soil lattice potassium varied from 4499 to 6910 mg kg^{-1} in surface, 6041 to 9125 mg kg^{-1} in sub-surface soils, respectively. In surface depth, lattice potassium was recorded highest in Gollarahosahalli (6910 mg kg^{-1}) soil and lowest in Madaba (4499 mg kg^{-1}) soil. The highest lattice potassium in sub-surface soil was recorded in Gowdgere (9125 mg kg^{-1}) soil and lowest in Dasarighatta (6041 mg kg^{-1}) soil. The mean content of lattice K was 5603 and 7431 mg kg^{-1} in surface and sub-surface soils, respectively. Lattice potassium contributes 90.28 per cent to total K in surface soil and 90.76 per cent in sub-surface soil of coconut gardens of southern dry zone of Hassan district (Table 3, Fig. 2).

The significantly high values of lattice potassium in coconut land use systems indicate that these soils have been derived from potassium bearing minerals such as 2:1 type of clay minerals which favoured the lattice potassium content in soils. The present results are corroborated with the findings of Divya *et* *al*. (2016); Harsha and Jagadeesh (2017). The contents of lattice K was relatively higher at sub-surface soils. This was mainly due to the difference in the intensity of weathering in the surface and sub-surface soils, the intensity being more in upper soils compared to the lower soils of soils.

3.6 Total potassium

The total potassium in surface depth of coconut growing soils of central dry zone varied from 4438.00 to 8500.00 mg kg^{-1} and in sub-surface soils ranged from 5625.00 to 10313.00 mg kg^{-1}, respectively. The surface total K was recorded highest in Byrambudhi (8500.00 mg kg^{-1}) soil and lowest in G. Shankaranahalli (4438.00 mg kg^{-1}) soil, respectively. Similarly, Byrambudhi (10313 mg kg^{-1}) and G. Shankaranahalli (5625.00 mg kg^{-1}) soil showed highest and lowest total K for sub-surface soils, respectively (Table 2, Fig. 2).

In case of coconut growing soils of southern dry zone, total potassium ranged from 5013.00 to 7650.00 mg kg^{-1} in surface and 6675.00 to 9925.00 mg kg^{-1} in sub-surface soils, respectively. The lowest total potassium was recorded in soils of Shravaneri (5013.00 mg kg^{-1}) and highest in Gollarahosahalli (7650.00 mg kg^{-1}) for surface soils. In sub-surface soils, highest total potassium was observed in Gowdgere (9925.00 mg kg^{-1}) soil and lowest in Dasarighatta (6675 mg kg^{-1}) soil, respectively (Table 3, Fig. 2).

The mean total potassium of central dry zone soils of Hassan district was 6509 mg kg^{-1} in surface soil and 8032 mg kg^{-1} in sub-surface soil and in southern dry zone soils was 6206.00 mg kg^{-1} and 8188.00 mg kg^{-1} in surface and sub-surface soils, respectively. The highest total K was recorded in central dry zone soil compared to southern dry zone soil in surface soil. A reverse trend was also noticed with respect to sub-surface soils.

The central dry zone soils were found rich with average total potassium compared to southern dry zone soil of coconut growing areas of Hassan district. It may be because of the rich K-bearing minerals in their lattice structure (Anil *et al.,* 2009). The high content of total potassium in these soils might be attributed to the dominance of potassium bearing primary minerals such as mica in clay fraction. Similar results were reported by Ranganathan and Sathyanarayana (1980), Raskar and Pharande (1997), Singh *et al.* (2001).

4.Conclusion

The result of the present investigation on forms and distribution of potassium in central and southern dry zones of coconut growing areas of Hassan district of Karnataka suggested that maximum K content of the soils was non-exchangeable form which was mostly fixed up within the clay lattice rendering very small amount of available K to plant. Henceforth, regular applications of K fertilizers will prevent K deficiency in coconut gardens. On sandy soils, or those having little cation exchange capacity, controlled-release K sources are much more effective than the easily leached water-soluble K sources. Application of resin coated K_2SO_4 @ 3-4 kg/tree, four times a year can mitigate potassium deficiency in coconut palm. Advance practices like root feeding of 200ml of 1% KCL per tree thrice a year have a profound influence in overcoming K deficiency. Knowledge of different forms of potassium in soil together with their distribution has greater relevance in assessing the long-term K supplying power of soil to coconut palm and is important in formulating a sound fertilizer program for a given set of soil and crops. This may help the planners to formulate an effective potassium fertilizer program in general for a zone, particularly for a soil type.

5. References

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Table 1: Location details of soil samples collected from central dry zone (Arasikere taluk) and southern dry zone (Channarayapatna taluk) of coconut growing areas of Hassan district, Karnataka

Sl. No.	Central dry zone	Southern dry zone	Sl. No.	Central dry zone	Southern dry zone
1	Thimlapura	Annenahalli gate	26	Shayanagiri	Doddakaradevu
2	Uttaradevanahalli	Katrighatta	27	Padavanahalli	Kundur
3	Nagarahallikatta	Doddmatthagatta	28	Tudikenahalli	Madanahalli
4	Lingapura	Settyhalli	29	J. C. Pura	Bagur
5	Aaldahalli	K. Hosur	30	Rampura	Nellur
6	Aaldahalli	Boodhikere	31	Holelkere	Kuruvanka
7	B. K Hosuru	Akkanahalli	32	Chikkametikurike	Shravaneri
8	Somashettihalli	Lakshmipura	33	Doddametikurike	Byaladakere
9	Chandanahalli	Narihalli	34	Megalagollarahatti	Malekopplu
10	Mullikere	Annenahalli	35	Yerehallikopplu	Sathenalli
11	S Diggenahalli	Badalpura	36	K. Shankarahalli	Navile
12	Gandasi	Doddakaradevu	37	Konanakatte	Didaga
13	Bachenahalli	Doddakaradevu	38	Hosakalyadi	Dasarigatta
14	Giddegowdanakopplu	Agrahara	39	Gundavanahalli	Byrapura
15	Yedunahalli	Vaaranahalli	40	Kanakanchenahalli	Bindiganavile
16	Gollarahalli	Ankenahalli	41	Thimmanahalli	Tagadur
17	Gundha	Yeliyuru kopplu	42	Odeyarhalli	Gowdgere
18	Dummenahalli	Madaba	43	Singhanahalli	Gollarahosahalli
19	Rudranahalli	Gulasindha	44	Singhanahalli	Vaddarahalli
20	Borahalli	Chikkanayakanahalli	45	Byrambudhi	Sorekaipura

21	Bhageshwara	Koordalli	46	Bendekere	Santhebachanahalli
22	Nagatthalli	M. shura	47	Kuruvangavalli	Jogipura
23	Gollarahatti	Kembalu	48	Nagasamudra	Bediganahalli
24	G. Shankaranahalli	Kembalu baaguru	49	Sappnalli	Janivara
25	G. Shankaranahalli	Kembalu	50	Kadakatte	Kantharajpura

Table 2: Forms and distribution of potassium in soil samples collected from central dry zone (Arasikere taluk) of coconut growing areas of Hassan district, Karnataka

Sample No.	Water soluble K (mg kg^{-1})		Hot water-soluble K (mg kg^{-1})		Exchangeable K (mg kg^{-1})		Non-exchangeable K (mg kg^{-1})		Lattice K (mg kg^{-1})		Total K (mg kg^{-1})	
	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)
1	3.32	2.58	9.06	7.32	58.22	50.45	538.46	757.38	7375	8502	7975	9313
2	2.64	2.22	8.67	7.08	47.35	38.71	590.01	733.08	6310	8126	6950	8900
3	2.40	2.04	7.74	6.15	58.38	49.09	637.97	756.08	6814	8193	7513	9000
4	2.88	2.34	9.21	7.62	59.72	51.06	598.83	677.00	6164	6782	6825	7513
5	3.04	2.50	10.59	9.00	56.04	46.13	483.35	631.38	5158	6583	5700	7263
6	2.28	3.16	8.82	6.81	64.10	55.52	424.09	766.93	4610	5212	5100	6038
7	1.96	2.68	10.92	8.91	47.31	37.17	585.62	615.35	6678	6682	7313	7338
8	1.36	3.70	6.12	4.11	42.74	56.78	582.92	598.73	5710	6353	6338	7013
9	1.74	4.00	8.22	6.93	46.69	36.03	507.31	567.58	5494	5905	6050	6513
10	3.96	4.48	9.66	7.65	60.37	52.35	584.78	673.58	6213	6907	6863	7638
11	4.28	4.22	10.86	8.85	59.37	52.01	455.37	513.78	4818	5530	5338	6100
12	3.82	3.08	8.25	6.24	48.80	67.10	644.64	735.83	7015	8257	7713	9063
13	2.32	3.14	6.87	5.46	69.46	60.34	541.02	666.13	5650	7333	6263	8063
14	1.54	4.00	9.45	8.04	49.65	38.98	486.93	607.03	4537	6913	5075	7563
15	1.62	4.14	9.90	8.49	51.78	39.46	652.89	775.60	6169	7956	6875	8775
16	1.56	3.74	9.66	8.25	57.53	48.69	455.26	575.98	4773	5672	5288	6300
17	1.92	3.76	12.99	11.58	52.23	42.22	485.38	608.83	4648	6695	5188	7350
18	2.98	2.12	9.66	8.25	63.22	56.53	544.39	693.75	6002	7085	6613	7838
19	2.66	1.80	12.66	11.07	40.16	33.78	521.92	615.63	5823	6511	6388	7163
20	2.04	1.18	11.10	9.51	51.59	44.30	501.60	643.33	5145	6586	5700	7275
21	1.70	1.66	8.76	7.17	68.30	66.99	609.43	731.75	6758	7612	7438	8413
22	1.96	2.08	10.35	8.76	61.47	55.80	478.62	628.53	4183	6364	4725	7050
23	3.34	2.48	10.86	9.57	66.47	57.70	510.56	670.23	5795	7082	6375	7813
24	3.50	3.10	8.04	6.75	64.88	49.68	606.03	675.23	7088	6910	7763	7638
25	1.20	1.10	6.03	4.02	39.38	62.55	404.23	476.35	3993	5085	4438	5625
26	3.50	3.28	8.37	7.08	44.00	42.57	615.55	796.55	6774	8145	7438	8988
27	3.74	3.08	10.89	9.60	53.73	43.52	557.90	693.00	5835	7098	6450	7838
28	3.66	3.00	8.82	7.53	47.04	40.40	614.46	812.20	6497	8744	7163	9600
29	3.74	3.08	9.03	7.74	67.11	28.17	567.37	734.75	5749	7434	6388	8200
30	3.44	2.78	8.70	7.41	50.06	42.77	635.49	825.65	6924	7179	7613	8050
31	2.14	1.48	8.22	6.93	67.22	59.50	585.80	734.63	5932	7779	6588	8575
32	2.78	2.12	8.31	7.02	50.99	41.53	573.01	727.55	6286	7829	6913	8600
33	1.76	1.10	8.64	7.35	64.55	56.68	450.42	593.03	4458	5424	4975	6075
34	2.94	2.28	9.12	7.83	60.76	54.50	584.97	755.63	5851	8575	6500	9388
35	3.18	2.24	7.74	6.45	65.31	57.84	491.23	686.73	4703	6853	5263	7600
36	3.36	2.42	8.64	6.93	39.87	34.11	585.93	747.88	5533	8103	6163	8888
37	1.90	1.22	9.72	8.01	49.70	41.41	598.08	793.78	6688	8064	7338	8900

Table 2 Cont…

Sample No.	Water soluble K (mg kg^{-1})		Hot water soluble K (mg kg^{-1})		Exchangeable K (mg kg^{-1})		Non-exchangeable K (mg kg^{-1})		Lattice K (mg kg^{-1})		Total K (mg kg^{-1})	
	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)
38	2.16	1.22	9.57	7.86	43.99	34.93	578.87	743.05	6587	7796	7213	8575
39	2.28	1.34	8.94	7.23	41.53	34.36	558.06	768.70	6386	8583	6988	9388
40	1.82	1.36	10.41	8.70	69.78	59.37	574.29	669.68	6554	6932	7200	7663
41	1.74	1.40	9.81	8.10	61.77	52.25	644.06	735.95	7055	8598	7763	9388
42	3.62	3.28	8.52	6.81	69.66	60.15	552.64	710.18	5637	7314	6263	8088
43	4.16	3.14	9.72	8.31	39.39	32.29	479.21	656.18	4715	6471	5238	7163
44	4.28	3.00	6.51	5.10	40.39	32.83	489.17	697.78	4804	6904	5338	7638
45	4.68	5.12	15.93	14.34	75.32	68.43	676.00	840.85	7744	9398	8500	10313
46	2.88	2.54	8.01	6.60	51.44	40.74	552.66	763.93	5781	8080	6388	8888
47	3.26	2.92	8.52	6.96	60.67	53.68	595.77	822.20	5953	8609	6613	9488
48	2.18	3.00	8.43	7.41	40.99	32.33	595.65	735.48	5999	7667	6638	8438
49	4.02	3.06	8.19	6.75	43.89	36.04	618.77	819.30	7096	8154	7763	9013
50	2.86	2.54	9.42	7.50	48.11	38.56	560.41	723.30	6339	7536	6950	8300
Range	**1.20-4.68**	**1.10-5.12**	**6.03-15.93**	**4.02-14.34**	**39.38-75.32**	**28.17-68.43**	**404.23-676.00**	**476.35-840.85**	**3993-7744**	**5085-9398**	**4438-8500**	**5625-10313**
Mean	**2.76**	**2.67**	**9.25**	**7.70**	**54.65**	**47.36**	**555.35**	**699.66**	**5896**	**7282**	**6509**	**8032**
S.D.	**0.90**	**0.96**	**1.70**	**1.71**	**9.97**	**10.60**	**63.83**	**81.88**	**901**	**995**	**959**	**1063**
C.V.	**32.68**	**36.05**	**18.35**	**22.18**	**18.25**	**22.37**	**11.49**	**11.70**	**15**	**14**	**15**	**13**

Table 3: Forms and distribution of potassium in soil samples collected from southern dry zone (Channarayapatna taluk) of coconut growing areas of Hassan district, Karnataka

Sample No.	Water soluble K (mg kg^{-1})		Hot water-soluble K (mg kg^{-1})		Exchangeable K (mg kg^{-1})		Non-exchangeable K (mg kg^{-1})		Lattice K (mg kg^{-1})		Total K (mg kg^{-1})	
	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)
1	2.56	1.82	8.25	6.36	39.37	30.98	529.48	662.00	5338	7072	5909	7767
2	2.96	1.38	8.01	6.30	52.94	49.32	486.48	629.30	4728	6365	5270	7045
3	3.24	2.70	4.29	6.54	60.41	48.28	560.56	704.63	5449	7512	6073	8267
4	3.38	2.84	9.72	8.01	50.44	44.96	478.86	622.20	4655	6630	5188	7300
5	3.28	2.74	11.10	9.39	42.35	38.11	478.31	632.35	4658	6746	5182	7419
6	3.04	2.50	9.33	7.62	45.87	35.48	517.89	693.63	5044	7406	5611	8138
7	2.70	2.16	11.43	9.72	63.14	56.49	472.67	676.95	4582	7207	5121	7942
8	2.76	2.22	6.63	4.92	55.05	49.66	483.37	639.33	4696	6675	5237	7366
9	3.30	2.56	6.54	6.66	49.78	40.22	598.21	772.03	5830	8080	6481	8895
10	2.50	1.76	10.17	8.46	39.44	31.44	493.72	637.20	4943	6671	5479	7342
11	2.76	2.02	11.37	9.66	67.57	59.81	608.24	757.78	6071	7911	6750	8731
12	2.50	1.76	8.76	7.05	47.55	41.04	563.73	742.80	5642	7773	6256	8558
13	2.96	2.22	7.38	5.67	65.59	58.33	554.84	718.65	5534	7501	6157	8280
14	3.30	2.56	9.96	7.65	48.67	40.02	595.20	801.83	5958	8394	6605	9238
15	2.30	1.56	9.21	6.90	49.85	39.42	617.87	799.43	6187	8370	6857	9211
16	2.50	1.76	8.97	6.66	60.50	53.69	502.65	676.15	5012	6777	5578	7509
17	2.70	1.96	12.30	9.99	46.63	63.42	478.04	664.63	6835	6651	7363	7381
18	3.28	2.42	10.50	6.09	68.66	61.76	452.67	626.23	4499	6264	5023	6954
19	2.96	2.10	11.97	9.66	72.65	63.53	480.15	604.38	4773	6042	5328	6712
20	2.28	1.42	10.41	8.10	54.66	43.96	501.04	636.23	5002	6384	5560	7065
21	2.18	1.74	8.07	5.76	50.51	44.19	660.91	809.28	6910	8132	7623	8987
22	2.66	3.02	9.66	7.35	47.77	38.13	536.53	690.05	5602	6932	6189	7663
23	3.76	2.90	10.17	8.76	39.60	32.80	567.65	641.90	5937	6451	6548	7128
24	2.90	2.04	7.53	6.12	40.98	34.94	506.47	653.83	5292	6570	5842	7261
25	2.86	2.00	7.35	5.94	50.40	42.15	580.17	729.05	6059	7763	6692	8536
26	3.34	2.68	7.68	6.27	61.66	30.97	578.06	787.95	6335	8404	6978	9226
27	2.54	1.88	10.20	8.79	45.15	38.32	520.28	635.40	5433	6764	6001	7440
28	2.92	2.26	8.13	6.72	63.75	55.94	648.53	747.80	6765	9050	7480	9856
29	3.10	2.44	8.34	6.93	39.04	33.29	498.02	693.48	5204	7390	5744	8120
30	2.68	2.02	7.68	6.27	49.84	43.38	544.91	728.20	5688	7753	6285	8526
31	3.28	2.62	7.20	5.79	57.96	51.11	514.99	684.28	5364	7274	5940	8012

Sample No.	Water soluble K (mg kg^{-1})		Hot water-soluble K (mg kg^{-1})		Exchangeable K (mg kg^{-1})		Non-exchangeable K (mg kg^{-1})		Lattice K (mg kg^{-1})		Total K (mg kg^{-1})	
	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)	Surface (0-30 cm)	Sub-surface (30-60 cm)
32	2.04	2.30	6.45	5.40	36.09	56.30	441.88	751.00	4533	7983	5013	8793
33	2.06	1.40	7.62	5.73	44.52	37.33	515.21	673.28	5550	7171	6111	7883
34	3.06	2.40	8.10	6.21	66.31	40.73	561.50	742.48	6030	7908	6660	8693
35	2.96	2.02	6.72	4.83	42.37	33.31	491.82	702.28	5297	7485	5834	8223
36	2.72	1.78	7.62	5.73	44.58	41.35	479.79	742.48	5164	7908	5691	8693
37	2.96	2.02	8.70	6.81	61.15	51.68	531.77	671.50	5712	7000	6308	7725
38	2.68	1.32	8.55	4.83	69.86	29.93	582.42	602.35	6254	6041	6909	6675
39	2.98	2.04	7.92	6.51	67.91	58.86	644.60	749.90	6185	7816	6900	8627
40	2.52	1.58	9.39	7.98	56.06	49.32	619.49	754.70	6146	7876	6824	8682
41	2.40	2.06	8.79	7.38	46.46	35.82	626.52	804.13	6226	8408	6901	9250
42	2.32	3.24	7.50	12.93	59.66	42.44	651.94	754.33	6467	9125	7181	9925
43	3.88	2.32	15.24	9.09	73.62	65.18	662.50	824.90	6910	8034	7650	8926
44	2.68	2.34	7.29	5.88	50.68	46.36	628.31	772.90	6239	8884	6921	9706
45	2.20	1.86	10.44	9.03	40.60	36.04	632.40	810.90	6610	8480	7285	9328
46	3.58	1.98	8.79	6.57	61.08	54.17	551.76	716.25	5575	7467	6192	8240
47	3.42	3.08	9.30	7.38	54.03	42.32	595.93	751.40	6034	7564	6687	8361
48	3.24	2.90	9.21	7.92	62.44	45.75	500.85	685.75	5054	6896	5620	7630
49	3.06	2.72	7.29	6.27	53.08	46.63	488.95	715.05	4942	7192	5487	7956
50	3.18	2.84	9.18	7.47	57.11	51.71	512.51	735.45	5178	7393	5751	8183
Range	**2.04-3.88**	**1.32-3.24**	**4.29-15.24**	**4.83-12.93**	**36.09-73.62**	**29.93-65.18**	**441.88-662.50**	**602.35-824.90**	**4499-6910**	**6041.00-9125.00**	**5013.00-7650.00**	**6675.00-9925.00**
Mean	**2.87**	**2.21**	**8.85**	**7.20**	**53.51**	**45.21**	**546.61**	**709.20**	**5603**	**7431**	**6206**	**8188**
S.D.	**0.43**	**0.48**	**1.83**	**1.59**	**9.95**	**9.72**	**61.36**	**60.70**	**677**	**774**	**733**	**829**
C.V.	**14.95**	**21.74**	**20.67**	**22.10**	**18.60**	**21.51**	**11.23**	**8.56**	**12.00**	**10**	**12**	**10**

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Fig. 1: Location map showing study area of Hassan district

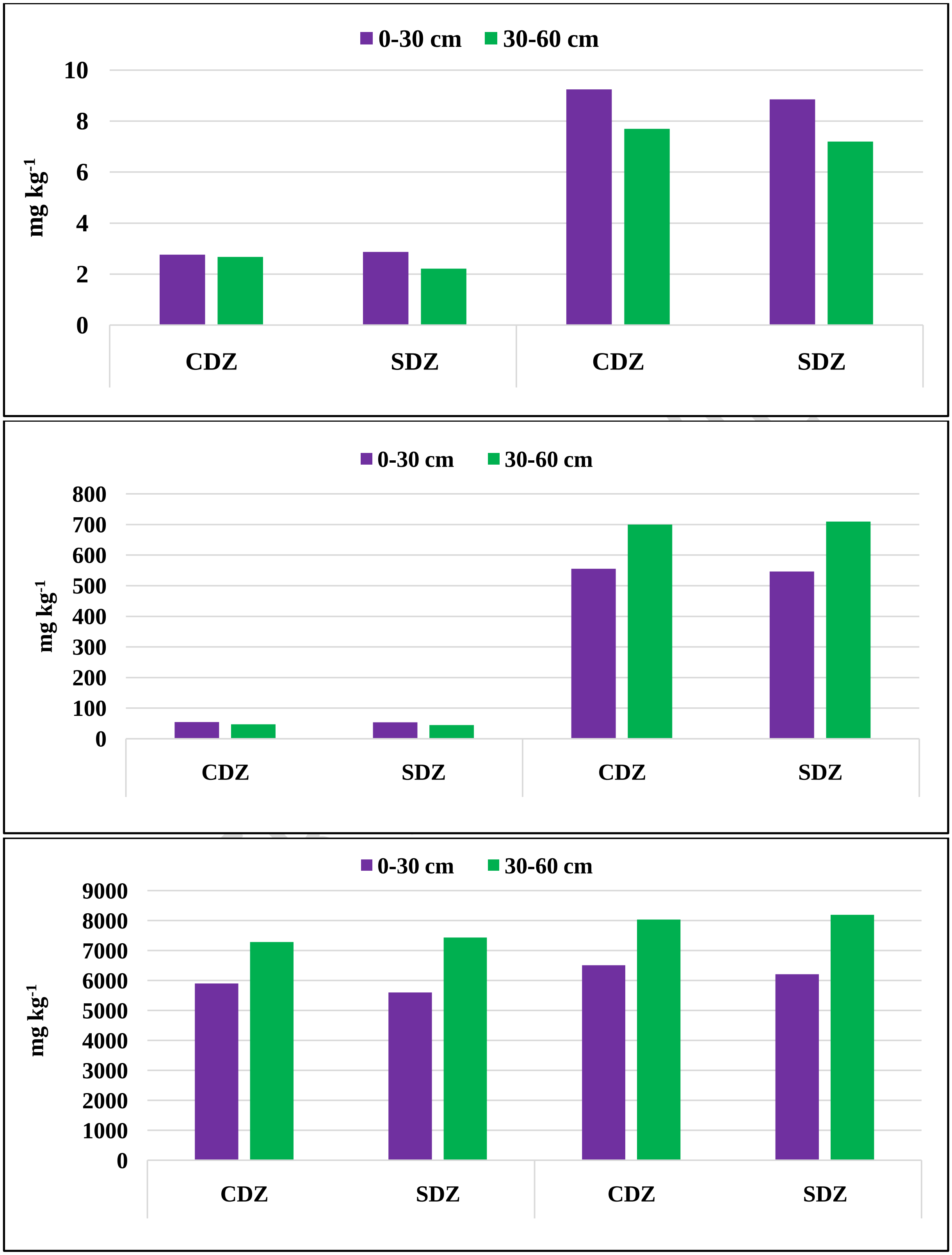

Fig. 2. Potassium fractions under central and southern dry zone of coconut growing areas of Hassan district, Karnataka