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# KINETICS OF POTASSIUM RELEASE IN MAJOR SUGARCANE GROWING SOILS OF TAMIL NADU INDIA

**D. Gokul[1*], P.K. Karthikeyan[2] and P. Poonkodi[3]**

[1]Department of Soil Science and Agricultural Chemistry, School of Agricultural Sciences, Dhanalakshmi Srinivasan University, Samayapuram, Trichy, Tamil Nadu. India.

[2]Department of Soil Science and Agricultural Chemistry, Department of Agroforestry, Forest College and Research Institute (TNAU), Mettupalayam, Coimbatore. Tamil Nadu, India.

[3]Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India.

*Corresponding author mail ID: gokuld.agri@dsuniversity.ac.in

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**ABSTRACT**

For investigating the potassium status and release characteristics of soil, surface (0-15 cm) and sub-surface (15-30 cm) soil samples from twelve soil series representing the major sugarcane growing regions of Tamil Nadu were collected. The soil texture, pH, EC and potassium release of surface and sub-surface soils in twelve sugarcane growing soil series were analyzed and recorded. Cumulative K release was calculated by summation of the amounts extracted in individual extractions. The quantity of potassium released with time was fitted in the four mathematical models (first order reaction, parabolic diffusion, elovich equation and zero order equation). These four mathematical models were tested for the least square regression analysis to determine which equations descried better the K release from the soils. Standard error and the coefficient of determinants ($R^2$) were obtained by measured vs. calculated values standard error of estimates were calculated. Potassium availability depends on soil potassium status and the rate of release of potassium to the solution phase. The highest mean value (0.999 and 0.998 in 0-15 cm and 15-30 cm depth, respectively) of co-efficient of determination and the lowest value (0.008 and 0.010 in 0-15 cm and 15-30 cm depth respectively) of standard error of estimate (SE) were observed in parabolic diffusion model in both surface and sub-surface soils. Hence, the parabolic function is the best fit model to describe the potassium desorption in major sugarcane growing soils of Tamil Nadu.

***Keywords*:** Potassium release, Models, sugarcane, soil series

## Introduction

Potassium is an essential macronutrient for sugarcane production and fulfills many important roles in healthy plant growth and better cane yield. It is a versatile nutrient, involved in biological processes including photosynthesis and the activation of plant enzymes. It also ensures crop productivity and quality. Sugarcane is a high- yielding crop that requires a lot of nutrients, with potassium being the one with the highest uptake and export, followed by nitrogen, calcium, magnesium, sulphur and phosphorus, which can be provided by mineral fertilizers. The response of sugarcane to potassium fertilizer application in low exchangeable soil potassium levels is significant and directly influences cane productivity (Korndorfer and Oliveira, 2005).

Moreover, the response of sugarcane to potassium fertilization is built upon the soil's available potassium (Oliveira *et al.,* 2018 and Korndorfer *et al.,* 2018). The sustainable production of sugarcane that aims to conserve resources and make even better use of them by the plant depends on deciding the correct fertilizer and applying it in the right amount. Potassium is necessary for the transfer of sugar in the metabolism of nitrogen, for the absorption, utilize, and transportation of water, and for the opening and closing of plant stomata. Additionally, it serves as a mechanism for holding water and stress resistance (Romheld and

Kirkby, 2010). Low production caused by slowly growing plants, reduced internodes caused by enzymatic respiration activation, and low photosynthetic responses are classic signs of insufficiency (Hasanuzzaman *et al.,* 2013). Potassium is the most readily absorbed and exported nutrient in sugarcane, it is linked to several structural and metabolic processes in plants, including stomatal opening, enzyme activation, and protein synthesis. (Jaiswal *et al.,* 2021). Potassium is necessary for the synthesis of sucrose from simple carbohydrates. By balancing sugar and acids, potassium improves product quality and aids in the synthesis and neutralisation of organic acids. Additionally, it fortifies tissues and cell walls and boosts nitrogen fertiliser efficiency (Mansouri, 2011).

The most significant chemical reaction in soils is desorption. After fertilizer application, the rate of potassium desorption varies depending on the soil because crops respond to supplied potassium earlier and because different soils desorb potassium differently, which causes its unpredictability. Up to 57% of the applied K can be absorbed by the clay colloids, depending on the quantity and kind of clay minerals (Shanwall and Dahiya, 2006). Compared to Illite and Vermiculite, certain clay minerals, such as Smectite and Kaolinite, readily release all of their absorbed K. (Kumari and Mohan, 2021). While the initial levels of the equilibrium solution serve as an indicator of potassium release, the rate at which plants remove potassium and the rate at which it can be desorbed phase (Jalali, 2006). The replenishment of a K deficient in soil solution, which is crucial for crop nutrition, is mostly caused by the release of potassium from clay minerals and organic matter. For ideal crop growth, exchangeable potassium and soil solution must be regularly replaced with K. This can be done by adding potassium fertilizer or releasing non-exchangeable potassium. Studies on the kinetics of potassium release from soil can help us understand how readily available potassium is to plants. The ways in which fertilizing soil with potassium affects its many components and how quickly potassium is released from the soil were studied to provide a pool of fundamental knowledge that can be beneficial for refining the current soil testing techniques for the prediction of potassium availability to sugarcane. In view of this context, a present study was conducted for potassium release kinetics of major sugarcane growing soil series of Tamil Nadu.

## Materials and Methods

The present investigation was carried out to find the potassium release kinetics of major sugarcane growing soil series of Tamil Nadu. Potassium availability depends on soil factors such as soil potassium status and the potassium release rate to the solution phase. The potassium release power in turn depends on the physico-chemical properties of the soils. Hence, for a critical appraisal of potassium status and releasing power of the major sugarcane growing soils of Tamil Nadu, laboratory studies were conducted. The surface soil (0-15 cm depth) and sub-surface (15-30 cm depth) soil samples were collected from twelve locations in the districts of Kallakurichi, Cuddalore, Erode, Villupuram, Namakkal and Thiruvannamalai. These districts are the major sugarcane growing areas of Tamil Nadu state (South India) and occupy an area of 84,908 hectares. They differed in their physico-chemical properties. The details of the twelve soil series were furnished in table 1.

The potassium release kinetics was carried out according to the method of Srinivasa Rao *et al.* (1998). Potassium release kinetics of major sugarcane growing soil series of Tamil Nadu were studied by shaking of 2.5 g soil sample with 25 ml of 0.01 M $CaCl_2$ extractant for 1 hour and equilibrated for 24 hours at 25°C. Following a centrifugation of these soil suspensions, the K supernatant solution was calculated using a flame photometer. The soil in the centrifuge tube was again extracted with flesh lot of 25 ml electrolyte solution and the whole process was repeated up to a total of 14 extractions. Cumulative K release was calculated by summation of the amounts extracted in individual extractions. The quantity of potassium released with time was fitted in the following mathematical models. Series wise twelve surface (0-15 cm depth) and sub-surface (15-30 cm depth) soil samples from the sugarcane growing area of Tamil Nadu were collected. Total equilibrium hours for extraction are 24 to 336 h.

Mathematical equations were studied for:

First order reaction : $\mathbf{Ln\ (K_0 - K_t) = a - bt}$

Parabolic diffusion : $\mathbf{K_t/K_0 = a + b\ t^{1/2}}$

Elovich equation : $\mathbf{K_t = a + b\ Ln\ t}$

Zero order equation : $\mathbf{K_0 - K_t = a - b\ t}$

Where, $K_0$ = maximum K released (mg $kg^{-1}$),

$K_t$ = Cumulative K released (mg $kg^{-1}$) at time t, t = time (h), a and b = Constants

The least square regression analysis was used to examine these six mathematical models in order to identify which equations best predicted the K release from the soils. Standard error and the coefficient of determinants ($R^2$) were acquired by least square regression of measured vs. calculated values standard error of estimates were calculated.

$$S.E. = [(Kt - K^*t)^2/(n-2)]^2$$

Where Kt and K*t represents the measured and calculated concentrations of K released at time t and n is the numbers of measurement made. All statistical analysis was carried out using a programme created in excel. The estimates' standard error was computed according to the formula described by Hossienpur *et. al.* (2012).

## Results and Discussion

The surface and sub-surface soil samples were collected from various locations representing the twelve soil series. The Pulavanur, Adanur, Irugur, Palladam, Arasanatham and Upparapatti soil series were classified under Inceptisols. The Vanur, Vadathesasalur, Vadamadurai and Kurumbalur soil series were classified under Alfisols. Pachol and Padugai soil series come under Entisols. Based on the results of the textural analysis, the twelve soil series were classified as clay (C), clay loam (CL), silty clay (SiC), sandy loam (SL), sandy clay loam (SCL) and loamy sand (LS). The data concerning pH, EC and textural properties of soil used for potassium release kinetic studies is given in table 2. From the table, the pH of the soils ranged from 6.9 to 8.2 with mean value of 7.61 in 0-15 cm depth and in 15-30 cm depth it varied from 7.0 to 8.2 with mean value of 7.67. The pH was observed that most of the soils were slightly acidic to slightly alkaline pH. The EC of the soils collected from sugarcane growing soil series ranged from 0.13 to 0.87 dS $m^{-1}$ with mean value of 0.34 dS $m^{-1}$ in 0-15 cm depth and 0.18 to 0.98 dS $m^{-1}$ with mean value of 0.39 dS $m^{-1}$ in 15-30 cm depth. The electrical conductivity of all soils was observed less than 1 dS $m^{-1}$ i.e., soil is good for the growth of crops.

The soils of twelve sugarcane growing tracts of Tamil Nadu, were tested for the various textural fractions. The results indicated that the texture of the twelve soils ranged from clay to loamy sand. Most of the soils contain higher amount of fine fractions (clay+silt) than coarse fractions (sand). Soil reactions studies indicated that the most of the soils were neutral condition.

### Potassium release kinetics

The release of the adsorbed potassium in different soil series of sugarcane grown soil over 336 hours extracted at every 24 hours in two different depth of soil is depicted in the fig.1 (surface soil) and 2 (sub-surface soil). The release of adsorbed potassium in all the soil series was higher in 0-15 cm than 15-30 cm depth.

The data furnished to the release of potassium over a period of 336 hours using 0.01 M $CaCl_2$ extractant in twelve sugarcane growing soil series of Tamil Nadu. In surface (0-15 cm) soil, the maximum amount of K desorbed was 80.7, 51.1, 146.9, 49.7, 124.2, 49.7, 61.4, 54.1, 82.2, 35.3, 114.4 and 37.1 mg $kg^{-1}$ in case of Vanur series, Vadathesasalur, series, Pachol series, Vadamadurai series, Pulavanur series, Adanur series, Padugai series, Irugur series, Palladam series, Arasanatham series, Upparapatti series and Kurumbalur series respectively in 24 hours extraction.

However, the minimum potassium desorption of 11.6, 11.8, 12.3, 10.3, 16.3, 10.5, 13.4, 13.9, 12.8, 10.2, 12.7 and 9.8 mg $kg^{-1}$ were recorded in Vanur series, Vadathesasalur, series, Pachol series, Vadamadurai series, Pulavanur series, Adanur series, Padugai series, Irugur series, Palladam series, Arasanatham series, Upparapatti series and Kurumbalur series respectively in 336 hours of extraction. In sub-surface (15-30 cm) soil, the maximum amount of K desorbed was 38.7, 28.3, 87.5, 29.4, 77.4, 26.3, 38.4, 33.1, 73.3, 31.1, 72.1 and 33.6 mg $kg^{-1}$ in case of Vanur series, Vadathesasalur, series, Pachol series, Vadamadurai series, Pulavanur series, Adanur series, Padugai series, Irugur series, Palladam series, Arasanatham series, Upparapatti series and Kurumbalur series respectively, in 24 hours extraction. However, the minimum amount potassium desorption of 10.7, 9.2, 9.4, 8.1, 14.9, 7.7, 13.1, 10.7, 14.3, 8.7, 12.7 and 9.6 mg $kg^{-1}$ were recorded in Vanur series, Vadathesasalur, series, Pachol series, Vadamadurai series, Pulavanur series, Adanur series, Padugai series, Irugur series, Palladam series, Arasanatham series, Upparapatti series and Kurumbalur series respectively, in 336 hours of extraction. Irrespective of the period of desorption times, the maximum desorption of potassium was noticed in Pachol soil series followed by Pulavanur and Upparapatti soil series. The least amount of desorption of potassium was noticed in Arasanatham soil series and all over soil series intermediately.

The release of adsorbed potassium was more drastic in all soil series within 96 hours and release was gradual until 336 hours. However, at the end of 336 hours of extraction, the amount of release of adsorbed potassium between soil series was all most comparable compared to initial period. The same trend was noticed in the sub-surface soil. The average release of adsorbed potassium across the soil series was 73.9, 46.7, 33.6, 25.9, 21.9, 20.3, 19.4, 17.6, 16.8, 15.7, 15.1, 14.5, 13.6 and 12.1 mg $kg^{-1}$ in 0-15 cm depth and 47.4, 33.6, 27.3, 23.7, 20.0, 16.7, 15.1, 14.3, 13.6, 13.0, 12.4, 12.0, 11.4 and 10.8 mg kg$^{-1}$ in 15-30 cm depth at 24, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, 312 and 336 hours of extraction, respectively.

The different potassium forms of twelve soil series are valuable in deciding the dose and type of potassium sources. These forms could indicate the soil efficiency in supply of potassium based on which one could access the potassium need. Therefore, it is essential to analyze the K release using various kinds of kinetic equations and fix the one equation that performed better than others in describing the desorption pattern. The findings revealed that data from laboratory research on potassium release and kinetics equation parameters can be used to assess the K-supplying capability of soils. Potassium desorption significantly decreased as time increased. Potassium content declining with increasing time was also reported by Brar *et. al.,* (2008) and Rezaei and Naeini (2009a). Up to 120 hours, the potassium release is rapid; beyond that time, it slows down. The major soil series used to cultivate sugarcane showed significant variation in the release of potassium. In order to create cumulative release curves, the potassium that was desorbed from the soil samples in 24–336 hours was cumulatively added and plotted against the cumulative desorption and time (table 3 for surface soil and table 4 for sub-surface soil).

The mean cumulative potassium desorbed (released) from the 12 soil samples were in the range of 229.3 to 513.2 mg kg$^{-1}$ in surface soil and 180.6 to 395.8 mg kg$^{-1}$ in sub-surface soil. In surface soil, the maximum cumulative potassium release of 513.2 mg kg$^{-1}$ was recorded in Pachol series and the minimum cumulative release of 229.3 mg kg$^{-1}$ was recorded in Arasanatham series. In sub- surface soil, the maximum cumulative potassium release of 395.8 mg kg$^{-1}$ was recorded in Palladam series and the minimum cumulative release of 180.6 mg kg$^{-1}$ was recorded in Adanur series. The similar type of cumulative potassium release was also studied by Bhat *et al.* (2023), Ghiri *et al.* (2023) and Hosseinpur *et al.,* (2012).

The surface soil (0-15 cm depth) had significantly greater potassium than that of sub-surface soil (15-30 cm depth). This might be attributed to the spread of crop residue, organic manure and other inputs. The potassium in sub-surface soil may be depleted due to improper soil mixing and manure application (Srinivasarao *et al.,* 2014). The differences observed in the total K desorption across different soils indicate that the cations that are absorbed onto the surface of clay micelles will impact the rate of K desorption. Lower values of the cumulative K quantity could be the result of the calcium exchanging potassium on the clay structure's surface in the calcium and potassium system. Once potassium has been exchanged on these sites, further calcium would interchange potassium less quickly (Razaei and Naeini, 2009). The nature of the potassium-bearing minerals, which may include the soil environment, chemical composition, layer charge modification, and crystal structure, may be the cause of the cumulative potassium release (Taiwo *et al.,* 2018) and Srinivasarao *et al.* (2010).

The release of potassium was influenced by the initial qualities of the soils, particularly organic carbon, cation exchange capacity and clay content (Kee Kwong and Ramasawmy Chellen, 2006). Biswas (2008) reported that Release of potassium is influenced by the soil clay mineralogy and texture, and it decreases rapidly with time. The variance in potassium desorption rates between soil series suggests that the rate of potassium desorption was influenced by the cations that were maintained on the surface sites (Patil *et al.,* 2018). The cation exchange and diffusion processes involved in the release of interlayer potassium ions from clay minerals like mica to the soil exchangeable phase, it takes time for the exchangeable cation to arrive at the site and the exchangeable potassium ion to diffuse out of the wedge zones of the micaceous minerals. It takes significantly longer for $K^+$ to diffuse cationically across the negatively charged wedge zone, and the K release process is often diffusion-controlled (Bell *et al.,* 2020).

## Different Kinetic models to describe potassium desorption

The potassium release from twelve soil series of major sugarcane growing areas were studied for 336 hours continuously with every 24 hours release of potassium and the data were fit into four mathematical models *viz.,* First order reaction, Parabolic diffusion, Elovich equation and Zero order equation to find out best potassium kinetic model to describe potassium release.

The data pertaining to the co-efficient of determination ($R^2$) and standard error of estimate (SE) of various kinetic models tested for cumulative potassium desorption in major sugarcane growing soil series of Tamil Nadu. Four mathematical models were used to describe the kinetics of potassium release in twelve soil series in both surface and sub-surface soils. These four kinetics equations were tested by least square regression analysis for describing the potassium desorption from soil exchange complex from twelve soil series. The ranges and mean value of $R^2$ and SE values of first order reaction, parabolic diffusion, Elovich equation and zero order equation were given in table 15 and 16 respectively for surface and sub-surface soil.

**Co-efficient of determination ($R^2$)**

The perusal of the data from the table 5 revealed that the co-efficient determination ($R^2$) ranged from 0.903 to 0.940 with the mean value of 0.928 for first order reaction, 0.997 to 0.999 with the mean value of 0.999 for parabolic diffusion, 0.955 to 0.980 with the mean value of 0.971 for elovich equation and 0.959-0.981 with the mean value of 0.969 for zero order reaction in 0-15 depth. While in 15-30 cm depth, the co-efficient determination ($R^2$) ranged from 0.916 to 0.954 with the mean value of 0.933 for first order reaction, 0.984 to 0.999 with the mean vale of 0.998 for parabolic diffusion, 0.952 to 0.995 with the mean value of 0.969 for elovich equation and 0.923-0.984 with the mean value of 0.968 for zero order reaction.

**Standard error (SE)**

The standard error (table 6) ranged from 0.235 to 0.284 with the mean value of 0.254 for first order reaction, 0.006 to 0.013 with the mean vale of 0.008 for parabolic diffusion, 11.28 to 19.61 with the mean value of 14.52 for elovich equation and 9.052 to 23.59 with the mean value of 15.43 for zero order reaction in 0-15 depth. While in 15-30 cm depth, the standard error ranged from 0.206 to 0.271 with the mean value of 0.241 for first order reaction, 0.007 to 0.028 with the mean vale of 0.010 for parabolic diffusion, 5.11 to 22.00 with the mean value of 12.40 for elovich equation and 8.34-19.52 with the mean value of 12.50 for zero order reaction. The first order reaction and parabolic diffusion were comparably capable in describing the potassium release data as indicated from higher $R^2$ value and lower standard error in both surface and sub-surface soils. Higher standard error values indicate that the zero-order equation and the elovich equation were not appropriate model to describe the potassium release kinetics, even though the $R^2$ value was higher in both surface and sub-surface soils of major sugarcane growing soil series. The highest mean value of co-efficient of determination ($R^2$) and the lowest value of standard error of estimate was observed in parabolic diffusion model in both surface and sub-surface soils. Hence, the parabolic function is the best fit for K desorption in sugarcane growing soils of Tamil Nadu.

Equation interactions between the soil solution K and exchange phase have a significant impact on the K supply to plants. Plant absorption of applied K is dependent on the rate and direction of these processes (Debankur Sanyal *et al.,* 2019), leached into lower soil horizons, changed into inaccessible forms, or liberated into accessible forms. For describing the kinetic data of potassium desorption, four kinetic models *viz,* first order reaction, parabolic diffusion, elovich equation and zero order equation were tested. The amount of potassium extracted peaked in the first extraction, decreased in the following extractions, and then was almost constant in the following extractions (Ghosh and Singh, 2001 and Azadi *et al.,* 2015). When examined using four different kinetic models, surface soil had higher potassium release rates than sub-surface soils due to its greater potential for potassium release.

The data pertaining to the co-efficient of determination ($R^2$) and standard error of estimate (SE) of various mathematical models tested for potassium desorption in sugarcane growing soil series of Tamil Nadu. Four kinetic models were used to describe the release kinetics of potassium in major sugarcane growing soil series. The coefficient of determination and standard error was derived from cumulative potassium release in both surface soil and sub-surface soil. In surface soil, the mean co-efficient of determination was 0.928, 0.999, 0.971, 0.969 and mean standard error was 0.254, 0.008, 14.52, 15.43 for first order reaction, parabolic diffusion, elovich equation and zero order equation, respectively. In sub- surface soil, the mean co-efficient of determination was 0.933, 0.998, 0.969, 0.968 and mean standard error was 0.241, 0.010, 12.40, 12.50 for first order reaction, parabolic diffusion, elovich equation and zero order equation, respectively.

It was demonstrated that it conforms to parabolic diffusion equation in heterogeneous soil systems of twelve soil series, as evidenced by the comparatively higher "$R^2$" and lower standard error value. These results are close accordance with the findings of Al-Silevany and Mehmedany (2023). Despite the fact that this equation described a diffusion-controlled mechanism, a nonlinear behaviour was found, that may be related to the film diffusion from exchange sites found in organic matter (Srinivasa Rao *et al*., 1998). Similar findings of potassium desorption from soils through Parabolic diffusion equation have previously been reported by Brar *et al.,* (2008), Mam-Rasul and Al-Obaidi (2011).

Our results were in conformity with the results of Hosseinpour and Kalbasi (2002), who found that the elovich equation and zero order equations could not describe the potassium release kinetics, on the basis of their lowest determination coefficient and highest values of standard error of estimate. It can be caused of depletion of potassium in the soil (Das *et al.,* 2022). In contrast, parabolic diffusion law explained the data satisfactorily, indicating diffusion-controlled exchange. The zero order equation has been relatively less used to describe the K kinetics and has attained less success (Umoh *et al.,* 2022 and Taiwo *et al.,* 2018). However, it demonstrated a greater ability to explain the K release from soils throughout extended periods of cropping than during shorter ones (Sen and Ghosh, 2011).

The elovich equation also failed to explain the release rates of K in soils. This is in consonance with the results reported by (Hosseinpur and Sinegani, 2007, Srinivasa Rao *et al.*1998 and Sharma and Swami, 2000). The intervals fixed in present study would have been longer for not getting this equation suited to describe the K desorption. Darunsontaya *et al.* (2010) reported that for applying the form of elovich equation, it is necessary to have precise release data at short intervals. The effectiveness of the Elovich equation in explaining K release kinetics should be evaluated in light of this fact. In both depths, the maximum coefficient of determination and minimal standard error of estimate were recorded by the parabolic diffusion model. In conclusion, the parabolic diffusion model is best fit model for potassium desorption in major sugarcane growing soil series of Tamil Nadu.

## Conclusion

From the present investigation, it can be concluded that the studies on potassium dynamics and release behavior varied between the twelve soil series of major sugarcane growing areas of Tamil Nadu. The highest mean value of co-efficient of determination ($R^2$) and the lowest value of standard error of estimate (SE) was observed under parabolic diffusion model in both surface (0-15 cm soil depth) and sub-surface (15-30 cm soil depth) soils. Hence, the parabolic function is the best fit for potassium desorption in sugarcane growing soils of Tamil Nadu.

**Table 1:** Details of sugarcane growing soil series of Tamil Nadu

| S. No. | Soil series | Symbol | Location | District | GPS reading | Classification |
|---|---|---|---|---|---|---|
| 1. | Vanur | Vnr | Puthuchimedu | Kallakurichi | 11.629773<br>79.104167 | *Vertic Haplustalf* |
| 2. | Vadathesasalur | Vds | Maniyanal | Kallakurichi | 11.982352<br>79.052306 | *Paralithic Rhodustalf* |
| 3. | Pachol | Phl | Valliyampattu | Kallakurichi | 11.851113<br>78.971813 | *Paralithic Ustorthent* |
| 4. | Vadamadurai | Vdm | Siruppanandal | Kallakurichi | 11.973341<br>79.048903 | *Typic Haplustalf* |
| 5. | Pulavanur | Plr | Keelarungunam | Cuddalore | 11.745519<br>79.667495 | *Vertic Ustropept* |
| 6. | Adanur | And | Manjakkollai | Cuddalore | 11.460467<br>79.573670 | *Fluventic Ustropept* |
| 7. | Padugai | Pdg | Sethiyathoppu | Cuddalore | 11.444701<br>79.548120 | *Typic Ustifluvent* |
| 8. | Irugur | Igr | Vadugapatti | Erode | 11.155917<br>77.719428 | *Typic Ustropept* |
| 9. | Palladam | Pld | Sivagiri | Erode | 11.126599<br>77.786559 | *Typic Ustropept* |
| 10. | Arasanatham | Anm | Aathikuppam | Villupuram | 12.071931<br>79.581334 | *Typic Ustropept* |
| 11. | Upparapatti | Upi | Sengapalli | Namakkal | 11.096713<br>78.060787 | *Typic Ustropept* |
| 12. | Kurumbalur | Kbr | Perunthuraipattu | Thiruvannamalai | 12.080826<br>79.006621 | *Typic Haplustalf* |

**Table 2:** Soil characteristics of major sugarcane growing soil series of Tamil Nadu

| S. No | Soil series | 0-15 cm dept | | | 15-30 cm depth | | |
|---|---|---|---|---|---|---|---|
| | | pH | EC (dS $m^{-1}$) | Texture | pH | EC (dS $m^{-1}$) | Texture |
| 1. | Vanur | 7.6 | 0.31 | Sandy clay loam | 7.8 | 0.35 | Clay |
| 2. | Vadathesasalur | 7.4 | 0.55 | Sandy clay loam | 7.4 | 0.58 | Sandy clay loam |
| 3. | Pachol | 7.2 | 0.26 | Sandy clay loam | 7.4 | 0.28 | Sandy clay loam |
| 4. | Vadamadurai | 7.4 | 0.24 | Silty clay | 7.5 | 0.29 | Silty clay |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. | Pulavanur | 7.7 | 0.29 | Clay loam | 7.7 | 0.33 | Clay loam |
| 6. | Adanur | 7.8 | 0.33 | Clay loam | 7.9 | 0.39 | Clay loam |
| 7. | Padugai | 8.2 | 0.22 | Loamy sand | 8.2 | 0.34 | Loamy sand |
| 8. | Irugur | 7.2 | 0.13 | Sandy loam | 7.3 | 0.18 | Sandy loam |
| 9. | Palladam | 7.8 | 0.18 | Sandy clay loam | 7.8 | 0.2 | Sandy clay loam |
| 10. | Arasanatham | 6.9 | 0.20 | Sandy loam | 7.0 | 0.21 | Sandy loam |
| 11. | Upparapatti | 7.8 | 0.87 | Silty clay | 8.1 | 0.98 | Silty clay |
| 12. | Kurumbalur | 8.2 | 0.52 | Clay loam | 8.2 | 0.57 | Clay loam |
| | Range | 6.9-8.2 | 0.13-0.87 | - | 7.0 -8.2 | 0.18 - 0.98 | - |
| | Mean | 7.61 | 0.34 | - | 7.67 | 0.39 | - |
| | SD | 0.38 | 0.21 | - | 0.39 | 0.23 | - |

**Table 3:** Cumulative potassium desorption (mg/kg) from the major sugarcane growing soil series of Tamil Nadu (0-15 cm depth)

| S. No | Soil series | Time (hours) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 24 | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 | 264 | 288 | 312 | 336 |
| 1 | Vanur | 80.7 | 127.6 | 155.3 | 179.2 | 198.6 | 217.6 | 236.4 | 251.9 | 266.3 | 280.3 | 294 | 307.5 | 319.8 | 331.4 |
| 2 | Vadathesasalur | 51.1 | 91.1 | 123.1 | 146.8 | 164.9 | 181.3 | 197.0 | 211.6 | 225.4 | 238.8 | 251.9 | 264.7 | 277 | 288.8 |
| 3 | Pachol | 146.9 | 221.2 | 261.4 | 291 | 319 | 346.4 | 372.2 | 396.6 | 419.7 | 441.5 | 462.2 | 482.7 | 500.9 | 513.2 |
| 4 | Vadamadurai | 49.7 | 85.4 | 117.3 | 138.7 | 158.2 | 175.6 | 191.7 | 206.9 | 220.7 | 233.9 | 246.7 | 258.2 | 269.3 | 279.6 |
| 5 | Pulavanur | 124.2 | 190.2 | 232.9 | 271.3 | 305 | 337.0 | 367.1 | 390.4 | 412.9 | 432.5 | 451.7 | 470.6 | 488.2 | 504.5 |
| 6 | Adanur | 49.7 | 84.9 | 111.4 | 131.9 | 148.1 | 163.0 | 177.2 | 190.5 | 203.2 | 215.7 | 227.4 | 238.7 | 249.8 | 260.3 |
| 7 | Padugai | 61.4 | 103.8 | 141.1 | 167.6 | 190.8 | 209.5 | 227.5 | 244.6 | 261.1 | 276.5 | 291.3 | 305.6 | 319.5 | 332.9 |
| 8 | Irugur | 54.1 | 97.9 | 130.2 | 155.6 | 174.8 | 192.5 | 209.9 | 226.9 | 243.7 | 258.8 | 273.6 | 288.0 | 302.1 | 316.0 |
| 9 | Palladam | 82.2 | 144 | 189.5 | 217.7 | 242.7 | 265.9 | 287.9 | 307.6 | 326.5 | 344.9 | 362.3 | 379.4 | 395.7 | 408.5 |
| 10 | Arasanatham | 35.3 | 64.5 | 90.0 | 107.9 | 122.1 | 136.1 | 149.8 | 162.3 | 174.4 | 186.0 | 197.3 | 208.4 | 219.1 | 229.3 |
| 11 | Upparapatti | 114.4 | 174.8 | 213.4 | 248.5 | 277.8 | 304.0 | 329.1 | 353.5 | 377.4 | 397.8 | 417.4 | 435.0 | 449.9 | 462.6 |
| 12 | Kurumbalur | 37.1 | 62.3 | 85.0 | 105.6 | 122.7 | 139.4 | 154.7 | 168.9 | 182.5 | 195.1 | 206.8 | 218.2 | 228.7 | 238.5 |
| | Mean | 73.9 | 120.6 | 154.2 | 180.1 | 202.1 | 222.4 | 241.7 | 259.3 | 276.2 | 291.8 | 306.9 | 321.4 | 335.0 | 347.1 |

**Table 4:** Cumulative potassium desorption (mg/kg) from the major sugarcane growing soil series of Tamil Nadu (15-30 cm depth)

| S. No | Soil series | Time (hours) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 24 | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 | 264 | 288 | 312 | 336 |
| 1 | Vanur | 38.7 | 63.5 | 86.2 | 108.1 | 127.8 | 144 | 159.6 | 173.4 | 186.7 | 199.6 | 211.8 | 223.3 | 234.5 | 245.2 |
| 2 | Vadathesasalur | 28.3 | 54.2 | 77.1 | 96.4 | 113.8 | 128.1 | 142.1 | 155.6 | 167.3 | 178.8 | 189.6 | 199.9 | 209.6 | 218.8 |
| 3 | Pachol | 87.5 | 132.6 | 165.0 | 194.2 | 213.9 | 229.1 | 241.4 | 252.2 | 262.7 | 273.0 | 283.1 | 293.0 | 302.7 | 312.1 |
| 4 | Vadamadurai | 29.4 | 56.2 | 80.7 | 100.9 | 115.9 | 128.4 | 140.5 | 152.2 | 163.7 | 174.9 | 184.6 | 193.9 | 202.5 | 210.6 |
| 5 | Pulavanur | 77.4 | 122.7 | 153.4 | 182.1 | 208.3 | 232.5 | 254.7 | 276.8 | 298.3 | 317.8 | 337.0 | 355.5 | 371.6 | 386.5 |
| 6 | Adanur | 26.3 | 49.5 | 68.8 | 85.3 | 99.6 | 111.0 | 121.1 | 130.5 | 139.5 | 148.3 | 156.7 | 165.0 | 172.9 | 180.6 |
| 7 | Padugai | 38.4 | 72.5 | 104.3 | 132.8 | 155.7 | 175.2 | 191.1 | 206.3 | 221 | 235.3 | 249.2 | 262.8 | 276.1 | 289.2 |
| 8 | Irugur | 33.1 | 63.5 | 89.9 | 113.0 | 133.3 | 151.2 | 165.9 | 179.1 | 191.7 | 203.7 | 215.5 | 227.0 | 238.2 | 248.9 |
| 9 | Palladam | 73.3 | 130.7 | 171.8 | 202.3 | 229.6 | 253.3 | 274.5 | 295 | 313.7 | 331.5 | 348.8 | 365.7 | 381.5 | 395.8 |
| 10 | Arasanatham | 31.1 | 60.7 | 85.0 | 105.3 | 122.7 | 135.7 | 148.4 | 160.7 | 172.6 | 183.6 | 194.3 | 204.5 | 214.3 | 223.0 |
| 11 | Upparapatti | 72.1 | 114.6 | 147.2 | 172.3 | 193.2 | 210.5 | 227.0 | 242.8 | 258.1 | 272.9 | 287.1 | 300.7 | 313.8 | 326.5 |
| 12 | Kurumbalur | 33.6 | 55.1 | 75.5 | 95 | 113.3 | 127.5 | 141.0 | 153.9 | 166.1 | 177.7 | 188.5 | 199.0 | 208.9 | 218.5 |
| | Mean | 47.4 | 81.3 | 108.7 | 132.3 | 152.3 | 168.9 | 183.9 | 198.2 | 211.8 | 224.8 | 237.2 | 249.2 | 260.6 | 271.3 |

**Table 5 :** Co-efficient of determination ($R^2$) of four mathematical models

| S. No | Soil Series | 0-15 cm depth | | | | 15-30 cm depth | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | First order | Parabolic diffusion | Elovich | Zero order | First order | Parabolic diffusion | Elovich | Zero order |
| 1 | Vanur | 0.931 | 0.999 | 0.974 | 0.967 | 0.929 | 0.999 | 0.955 | 0.981 |
| 2 | Vadathesasalur | 0.933 | 0.999 | 0.975 | 0.966 | 0.931 | 0.999 | 0.963 | 0.976 |
| 3 | Pachol | 0.903 | 0.998 | 0.971 | 0.969 | 0.954 | 0.984 | 0.995 | 0.923 |
| 4 | Vadamadurai | 0.934 | 0.999 | 0.974 | 0.967 | 0.932 | 0.999 | 0.973 | 0.967 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Pulavanur | 0.940 | 0.999 | 0.976 | 0.963 | 0.916 | 0.999 | 0.952 | 0.984 |
| 6 | Adanur | 0.930 | 0.999 | 0.971 | 0.970 | 0.936 | 0.999 | 0.973 | 0.968 |
| 7 | Padugai | 0.935 | 0.999 | 0.974 | 0.967 | 0.937 | 0.999 | 0.970 | 0.969 |
| 8 | Irugur | 0.930 | 0.999 | 0.968 | 0.973 | 0.937 | 0.999 | 0.970 | 0.969 |
| 9 | Palladam | 0.922 | 0.997 | 0.980 | 0.959 | 0.932 | 0.999 | 0.977 | 0.963 |
| 10 | Arasanatham | 0.926 | 0.999 | 0.964 | 0.976 | 0.929 | 0.999 | 0.972 | 0.968 |
| 11 | Upparapatti | 0.923 | 0.999 | 0.971 | 0.969 | 0.932 | 0.999 | 0.973 | 0.968 |
| 12 | Kurumbalur | 0.925 | 0.999 | 0.955 | 0.981 | 0.929 | 0.999 | 0.954 | 0.981 |
| | Range | 0.903-0.940 | 0.997-0.999 | 0.955-0.980 | 0-959-0.981 | 0.916-0.954 | 0.984-0.999 | 0.952-0.995 | 0.923 -0.984 |
| | Mean | 0.928 | 0.999 | 0.971 | 0.969 | 0.933 | 0.998 | 0.969 | 0.968 |

**Table 6:** Standard Error (SE) of four mathematical models

| S. No | Soil Series | 0-15 cm depth | | | | 15-30 cm depth | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | First order | Parabolic diffusion | Elovich | Zero order | First order | Parabolic diffusion | Elovich | Zero order |
| 1 | Vanur | 0.245 | 0.007 | 12.80 | 14.27 | 0.245 | 0.008 | 14.35 | 9.43 |
| 2 | Vadathesasalur | 0.236 | 0.010 | 11.74 | 13.86 | 0.247 | 0.008 | 11.88 | 9.66 |
| 3 | Pachol | 0.317 | 0.010 | 19.61 | 20.43 | 0.206 | 0.028 | 5.11 | 19.27 |
| 4 | Vadamadurai | 0.246 | 0.007 | 11.97 | 13.42 | 0.249 | 0.008 | 9.55 | 10.63 |
| 5 | Pulavanur | 0.238 | 0.009 | 18.89 | 23.59 | 0.271 | 0.009 | 22.00 | 12.62 |
| 6 | Adanur | 0.241 | 0.007 | 11.28 | 11.47 | 0.232 | 0.007 | 8.17 | 8.88 |
| 7 | Padugai | 0.235 | 0.008 | 13.96 | 15.65 | 0.227 | 0.008 | 13.98 | 14.15 |
| 8 | Irugur | 0.237 | 0.007 | 14.66 | 13.57 | 0.231 | 0.007 | 12.07 | 12.25 |
| 9 | Palladam | 0.272 | 0.013 | 14.46 | 20.56 | 0.247 | 0.010 | 15.31 | 19.52 |
| 10 | Arasanatham | 0.245 | 0.006 | 11.65 | 9.49 | 0.252 | 0.007 | 10.21 | 10.95 |
| 11 | Upparapatti | 0.284 | 0.006 | 19.20 | 19.84 | 0.237 | 0.008 | 13.12 | 14.35 |
| 12 | Kurumbalur | 0.257 | 0.008 | 14.06 | 9.05 | 0.246 | 0.010 | 13.07 | 8.34 |
| | Range | 0.235 -0.284 | 0.006 -0.013 | 11.28 -19.61 | 9.052-23.59 | 0.206 -0.271 | 0.007 -0.028 | 5.11 -22.00 | 8.34 -19.52 |
| | Mean | 0.254 | 0.008 | 14.52 | 15.43 | 0.241 | 0.010 | 12.40 | 12.50 |

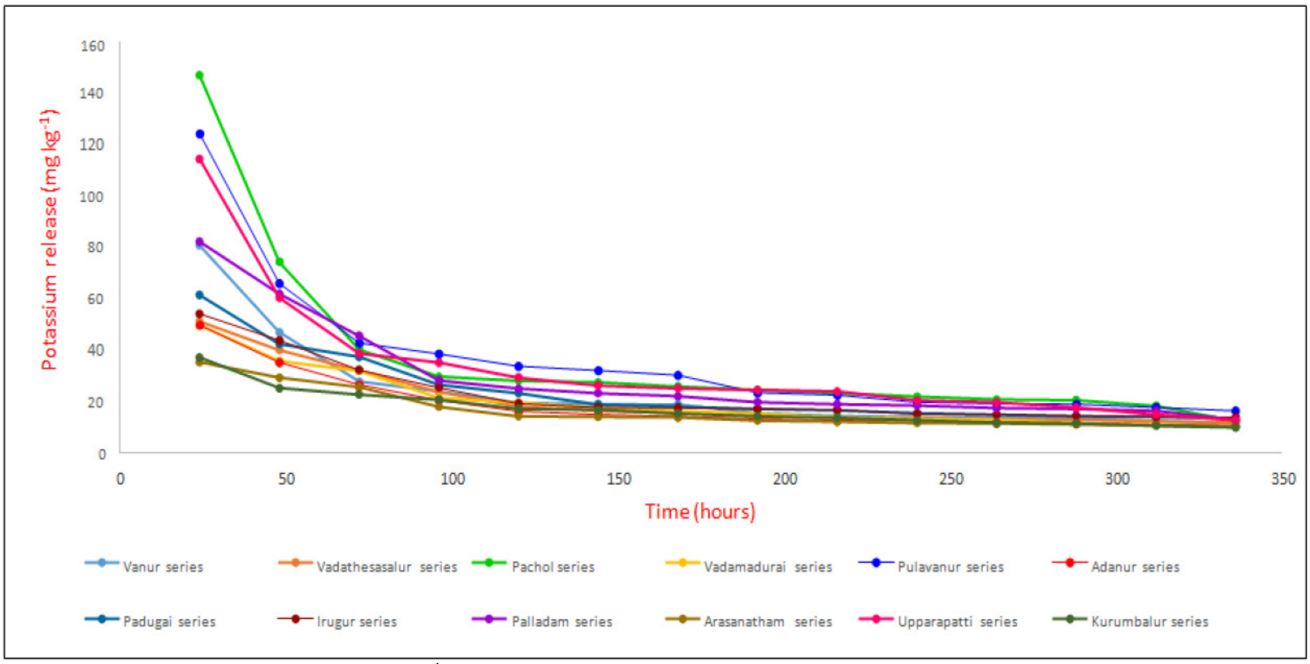


**Fig. 1 :** Potassium desorption (mg $kg^{-1}$) in major sugarcane growing soil series of Tamil Nadu (0-15 cm depth)

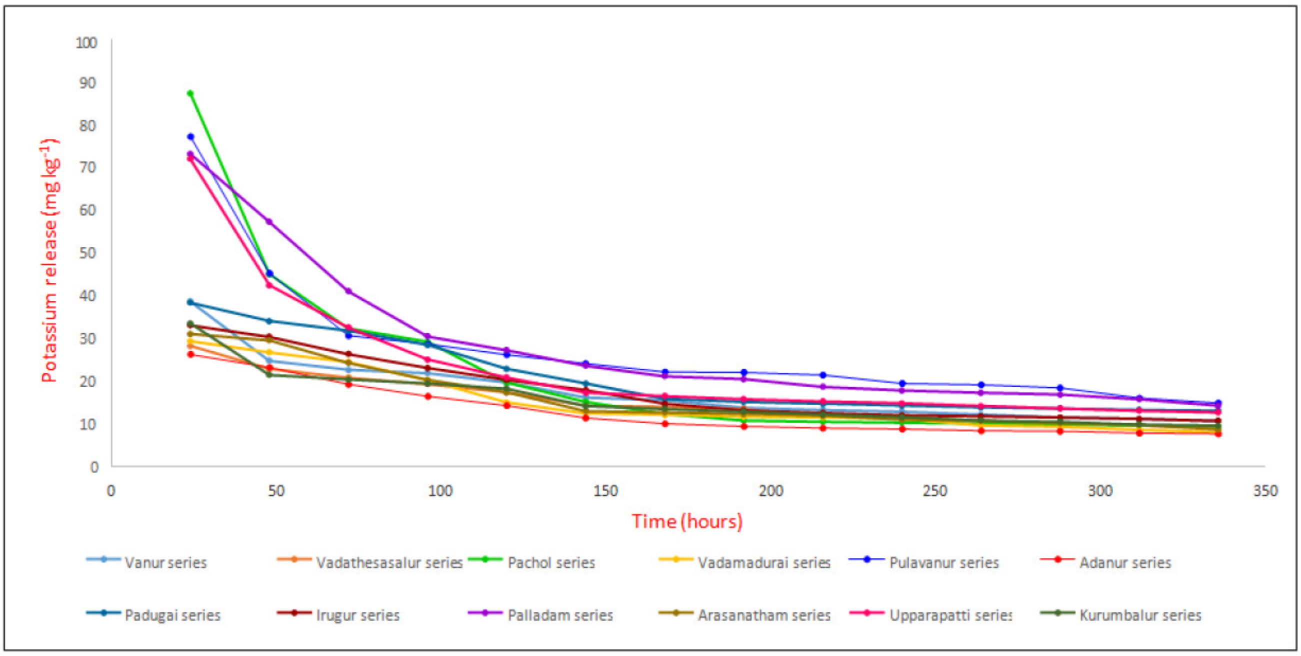


**Fig. 2 :** Potassium desorption (mg $kg^{-1}$) in major sugarcane growing soil series of Tamil Nadu (15-30 cm depth)

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