



Research Article

Mapping of Macro Minerals in Selected Summer Forages of District Kasur

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Abstract

Minerals are essential for production, reproduction and health of livestock. Among feed resources, forages are considered as a cheap source of minerals for livestock. Therefore, the aim of this study was to map the mineral contents of selected summer forages of district Kasur. Four seasonal forages including maize, sorghum and millet were selected for analysis of mineral contents. A total n=400 forage samples were collected from four tehsils of district Kasur including: Kasur, Chunian, Pattoki and Kot Radha Kishan (KRK). For Sample collection GPS essential android mobile application was used to determine latitude and longitude for sample collection site. After collection, samples were processed for wet digestion. Sodium (Na) and Potassium (K) content was analyzed using flame photometer; whereas, Calcium (Ca) and Phosphorus (P) contents were analyzed by atomic absorption and spectrophotometer. The data were analyzed using one-way Analysis of Variance (ANOVA). Results of the current experiment showed that Ca concentration was higher ($P<0.05$) in the Chunian compared with the KRK and Pattoki in maize forage. Additionally, sorghum Ca concentration was same ($P>0.05$) in the entire tehsils of the Kasur. Whereas, Ca contents of millet was higher ($P<0.05$) in the Kasur compared with the Chunian. Concentration of P in maize and sorghum forages were not different ($P>0.05$) among all the tehsils. Whereas, P contents of millet was higher ($P<0.05$) in the KRK compared with the Chunian. In maize forage, Na contents was higher ($P<0.05$) in the KRK compared with the Kasur and was lower in the Pattoki and the Chunian. Na concentration of sorghum forage was greater ($P<0.05$) in the Pattoki compared with the other tehsils. Whereas, Na contents of millet forage was higher ($P<0.05$) in the Chunian than the KRK. K contents of maize and millet forages were not different ($P>0.05$) among the all tehsils of the district Kasur. Whereas, K concentration was higher ($P<0.05$) in the KRK compared with the Kasur in sorghum forage. It can be concluded that concentration of Ca, P, N and K in summer forages including maize, sorghum and millet of district Kasur varied. Data can help us to identify the mineral deficiency in district Kasur and formulate area specific mineral mixtures to manage mineral status of livestock.

Keywords: Minerals; Summer forages; Mapping; Kasur.



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Introduction

Pakistan has a diverse and huge population of livestock including 38.8 million buffalo, 46.1 million cattle 30.5 million sheep and 74.1 million goats. At present, small scale and subsistence farmers constitute approximately 97.9% of livestock population in which animals are mainly fed on fresh green chop and crop residues. Conventionally, forages are classified as summer and winter forages and further subdivided into leguminous and non-leguminous. In Punjab, conventional summer season are predominated by cereal types of forage mainly maize, sorghum and millet. Recently, Habib *et al.* (2016) assessed the feed supply and demand for livestock and reported that different types of feed resources fed include: 23.8% fodder, 58.8% crop residue and 9.2% grazing; including 51% nutrients contributed by green fodder, 38% from crop residue and 3% from grazing.

The success of animal physiological potential depends upon proper and balanced nutrients supply (Underwood, 1981; Judson *et al.*, 1987). Minerals are inorganic compounds essential for production, reproduction and health of livestock. Minerals high in concentration are termed as macro minerals; whereas those required in smaller quantity are called micro minerals (NRC, 1996). Among macro minerals, Ca, Na and K are of great value in the livestock feeding. Briefly; calcium (Ca) and phosphorus (P) deficiency can cause weakening of bones, low milk production, poor growth, rickets and tetany (McDowell and Arthington, 2005). Similarly, sodium (Na) and potassium (K) are necessary for maintaining osmotic pressure, acid-base regulation, muscle contraction and water balance. Furthermore, heart function, nerve impulse conduction and transmission are reliant on the proper concentration of Na and K.

Mineral contents can vary between leguminous and non-leguminous seasonal forages. Imbalance in mineral contents in ruminant diets can induce certain pathophysiological changes including deficiency of minerals which may lead to delayed onset of puberty, reproductive failure (Hidiroglou, 1979; McDowell, 1985), low conception rate, poor growth, poor quality wool, retained placenta and high mortality (Proyecto *et al.*, 1979). Mineral deficiencies or excesses in livestock can be predicated by use of systematic mapping survey technique of a particular region. This technique mostly depends upon forage analyses (McKenzie, 1975; McDowell and Arthington, 2005).

Forages are a cheap source of minerals for livestock. Several factors can influence mineral contents of forages between forage specie (McDowell *et al.*, 1983; McDowell *et al.*, 1997), stage of maturity, soil condition (Jamal *et al.*, 2002; Islam *et al.*, 2003) and seasonal variation (Khan *et al.*, 2006a). Previous work by (Hannam *et al.*, 1980) revealed that mineral contents of forages varied greatly from forage to forage, location to location and soil to soil. In another work on mineral estimation Khan *et al.* (2007) concluded that forages in Punjab are deficient in sodium, calcium and potassium.

Keeping in view the importance of mineral and their variation, our objective was to determine the current status of mineral contents mainly Ca, P, Na and K in selected summer forages of district Kasur. Other objectives were to develop GIS develop maps and establish guidelines for formulating for area specific mineral mixture.

Methodology

Study Area and Sampling of Seasonal Forages

Samples of seasonal summer forages were collected from 04 tehsils of district Kasur located between 31.117865" North, 74.440839" East. Each tehsil was furthered divided into five sub-sites. A total of n=25 samples of each forage were collected from each tehsil (n=5 samples/sub-site/fodder). In this way, overall n=400 samples for forages were collected from entire district Kasur. Details of samples collection sites and sub sites are given in Figure 1.

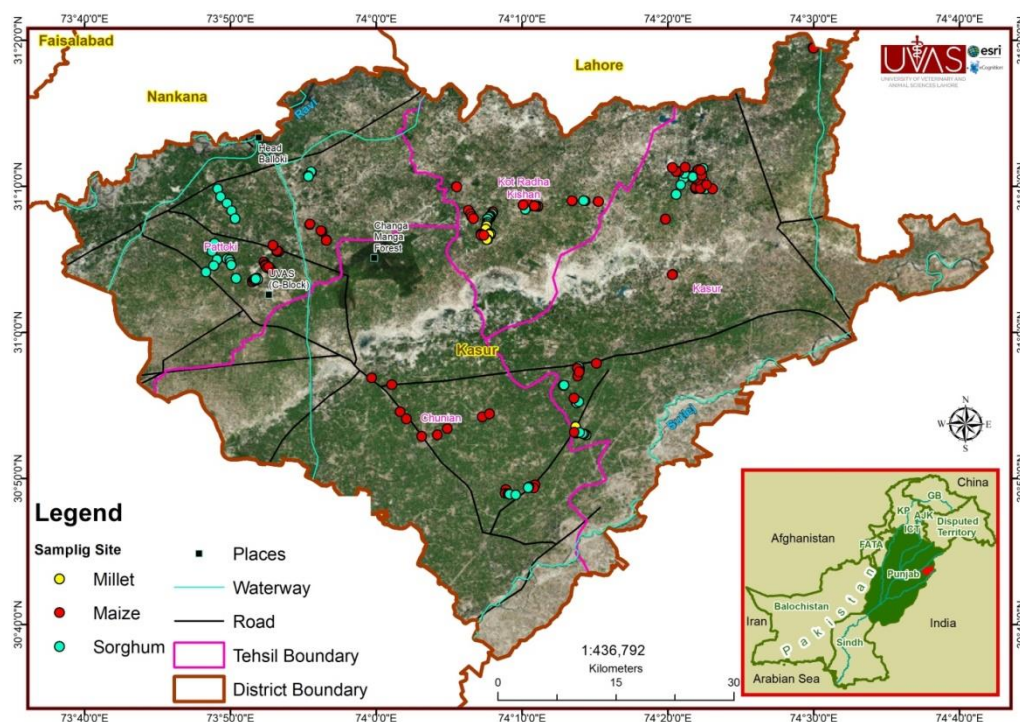


Figure 1: GIS Map of district Kasur for the collection of forage samples.

Mineral Mapping Using GIS Mobile Application

To determine the samples site for the collection, a GPS essential android mobile application was used to determine latitude and longitude of sample collection site. ArcGIS 10.5® was used to develop the spatial data base and prepare the data for the geo-statistical analysis. Inverse Distance Weighted (IDW) technique was used to find out the spatial trend of minerals in the study.

Forages Sampling and Labeling

Selected seasonal forages maize, millet and sorghum samples were collected randomly from each site. All weeds and soil was manually removed from the sample. To collect the representative sample, forage was chopped and reduced to desired samples size by the method of quartering. Collected samples were stored in an ice box and then transported to laboratory on same day.

Drying, Grinding and Labeling

Quartered samples were dried in hot air oven at 70 °C for 24 hours. After that each sample was ground in Wiley mill (A.H THOMAS, USA) using 1mm sieve.

Wet Digestion Procedure

Wet digestion was performed according to (Fick et al. 1979) briefly; dried and ground sample weighing approximately 0.5g was transferred to a 100 ml conical flask. Further, 10 ml of concentrated HNO₃ was added to the flask. After shaking, sample was heated at 60-70 °C for 15-20 minutes and then allowed to cool down. A 5 ml of per chloric acid (HClO₄) was added and heated at 70-80 °C for 15-20 minutes. Sample was heated again at 250-300 °C using a hot plate until the volume of solution was reduced to 1-2ml in flask. After this, filtration was performed using Watt man paper 2. The filtrate was diluted by adding 100 ml deionized water.

Mineral Analysis

Sodium (Na) and Potassium (K) analysis carried out using flame photometer (SPECTROLAB, UK). Whereas, Phosphorus and Calcium contents were analyzed using spectrophotometer (SPECORD, GERMANY) and atomic absorption (THERMO SCIENTIFIC, GERMANY) respectively.

Statistically Analysis

Data were subject to Komologrov Smirnov's to evaluate the normality of collected data. Collected data analyze Statistical Package for Social Sciences (SPSS) version 23.0. Mean \pm Standard deviation (SD) difference of mineral among four different tehsils of District Kasur, respectively were explore by using one-way Analysis of Variance (ANOVA) (Steel *et al.*, 1997).

Result and Discussion

Forage Calcium

Results of Ca concentration are given in Table 1. In maize forage, concentration of Ca was higher ($P < 0.05$) in the Chunian compared with the KRK and Pattoki. Additionally, sorghum Ca concentration was same ($P > 0.05$) in the entire tehsils of the Kasur. Whereas, Ca contents of millet was higher ($P < 0.05$) in the Kasur compared with the Chunian. Mean Ca contents present in irrigated forages are higher than the values observed by Bhagat *et al.* (2017). Our finding for Ca concentration of all the summer forages are in line to that document by previously in non-leguminous fodders cultivated in canal irrigated areas of Punjab (Khan *et al.*, 2009; Khan *et al.*, 2013). Ca concentration are present same in different forage as found in this study were reported by Pastrana *et al.* (1991) in Colombia, (Tiffany *et al.*, 2001) in North Florida, (Espinoza *et al.*, 1991) in Central Florida and (Cuesta *et al.*, 1993) in North Florida. Mean Ca contents from all forages and different sites were not in range to those mentioned in (NRC, 1996; Khan *et al.*, 2007; Khan *et al.*, 2004; Abdelrahman *et al.*, 1998). Means Ca contents in summer forages were deficient in all the tehsils. Variation in Ca contents of different summer forages of District Kasur can be attributed to variation in soil mineral contents, forage type, cultivation method, season variation, organic matter and use of fertilizer (Khan *et al.*, 2006b). Typically, forages conventionally grown summer cereal forages are low in calcium than that of legume forage. Main reason for low Ca in maize, sorghum and millet forages used in this study could be high ambient temperature, as majority of sampling was carried out during the months of July and August. Average rain is very high during months and that could also be a reason for low Ca contents. High temperature reduce the mineral contents in forages and sampling period of this study is summer season which too harsh and prolong in Pakistan.

Table 1. Calcium concentration (% DM) of selected summer forages in different tehsil's of Kasur District.

Forage	Tehsils of Kasur				S.E.M	P value
	Kasur	K R Kishan	Chunian	Pattoki		
Maize	0.317 ^{ab}	0.258 ^a	0.407 ^b	0.261 ^a	0.016	0.009*
Sorghum	0.292	0.354	0.324	0.263	0.016	0.209
Millet	0.326 ^c	0.293 ^{ab}	0.220 ^a	0.311 ^{ab}	0.020	0.037*

^{a, c} in a row, means with different superscripts are different significantly ($P < 0.05$)

Forage Phosphorus

Results of P concentration are given in Table 2. Concentration of P in maize and sorghum forages were not different ($P > 0.05$) among all the tehsils. Whereas, P contents of millet was higher ($P < 0.05$) in the KRK compared with the Chunian. Means P contents from all sites were relatively higher from the range that was documented in (NRC, 1996) except in the millet forage which was deficient in all the tehsil except in the KRK. Mean P concentration is almost similar to those reported by Satapathy *et al.* (2016). Fluctuation in

P concentration is related to many factors such as increase crop and fodder productivity, soil mineral contents, variation in the pH, fertilization of soil and the availability of competing elements to the forage, type of forage and the rate of forage growth. Mean P contents present in forages are higher than the values observed by (Bhanderi *et al.*, 2014; Bhagat *et al.*, 2017). P concentration in seasonal forages was higher and adequate in all tehsils of district Kasur because mostly farmers were used N fertilizer which was chief source of phosphorus in soil.

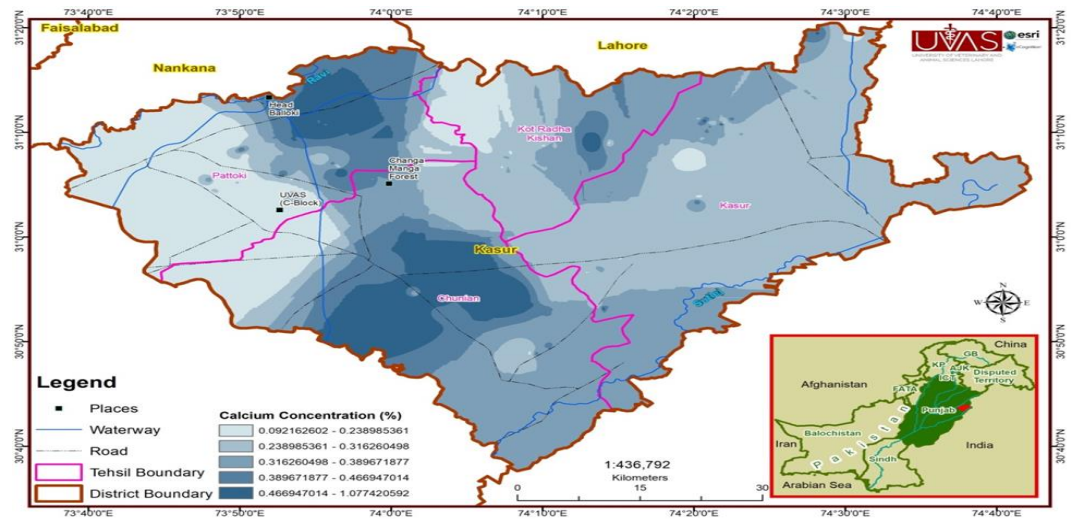


Figure 2. Calcium distribution in different tehsils of district Kasur and its fluctuation.

Table 2. Phosphorous concentration (% DM) of selected summer forages in different tehsil's of Kasur District.

Forage	Tehsils of Kasur				S.E.M	P value
	Kasur	K R Kishan	Chunian	Pattoki		
Maize	0.503	0.637	0.666	0.560	0.031	0.273
Sorghum	0.476	0.566	0.644	0.516	0.031	0.366
Millet	0.312 ^{ab}	0.434 ^b	0.195 ^a	0.263 ^{ab}	0.039	0.000*

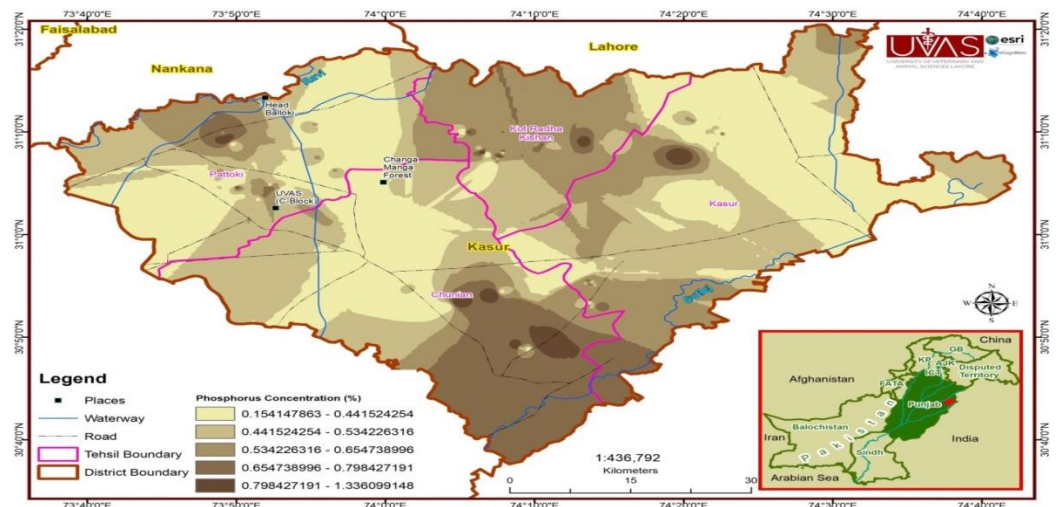


Figure 3. Phosphorus distribution in different tehsils of district Kasur and its fluctuation.

Forage Sodium

Results of Na concentration are given in Table 3. In maize forage, Na contents was higher ($P < 0.05$) in the K RK compared with the Kasur and was lower in the Pattoki and the

Chunian. Na concentration of sorghum forage was greater ($P < 0.05$) in the Pattoki compared with the other tehsils. Whereas, Na contents of millet forage was higher ($P < 0.05$) in the Chunian than the KRK. Mean Na concentration is almost similar in summer forages to those observed by (Khan *et al.*, 2004; Khan *et al.*, 2006b; Khan *et al.*, 2007) in canal irrigated areas of the Punjab. There is great impact of seasonal variation in the concentration of Na in the different forages which are generally cultivated in Pakistan. Generally summer forages have more Na concentration than the winter forages but it is also depends upon the soil nature, types of forage, age of maturity and use of organic fertilizers (Dierenfeld *et al.*, 1995; Khan *et al.*, 2006b). Na content values were below than the values suggested by (NRC, 1996; Sial, 1991; Khan *et al.*, 2009; Khan *et al.*, 2013). In Forages Na contents were lower than the critical values recommended by NRC (Tudsri and Kaewkunya, 2002). In millet forage was deficient in all the tehsils but maize forages were deficient in the Chunian and somewhere in the Kasur tehsil. Na contents in sorghum forage were deficient in all the tehsil except Pattoki. It's may be due to distribution of Na content in different forages and its bioavailability to animals. It might be due to high level of K level in forages also depressed the Na contents. On the basis of various analyses it is necessary to meet the requirements of highly productive animal there is need of Na supplementation in feed for their optimum livestock productivity. Na concentrations in seasonal forages indicated that the potential supply of these minerals to plants were limited from the soil which were usually used for animal feed (Khan *et al.*, 2009). Sampling period and high temperature during this study is a major reason for Na fluctuation in these forages. Water quality which is usually used for cultivation is different in aspect to all location because water quality is more alkaline in some tehsils.

Table 3. Sodium concentration (% DM) of selected summer forages in different tehsil's of Kasur District.

Forage	Tehsils of Kasur				S.E.M	P value
	Kasur	K R Kishan	Chunian	Pattoki		
Maize	0.066 ^b	0.180 ^c	0.009 ^a	0.20 ^a	0.005	0.000*
Sorghum	0.023 ^a	0.030 ^a	0.011 ^a	0.196 ^b	0.005	0.000*
Millet	0.009 ^{ab}	0.008 ^a	0.010 ^b	0.009 ^{ab}	0.007	0.041*

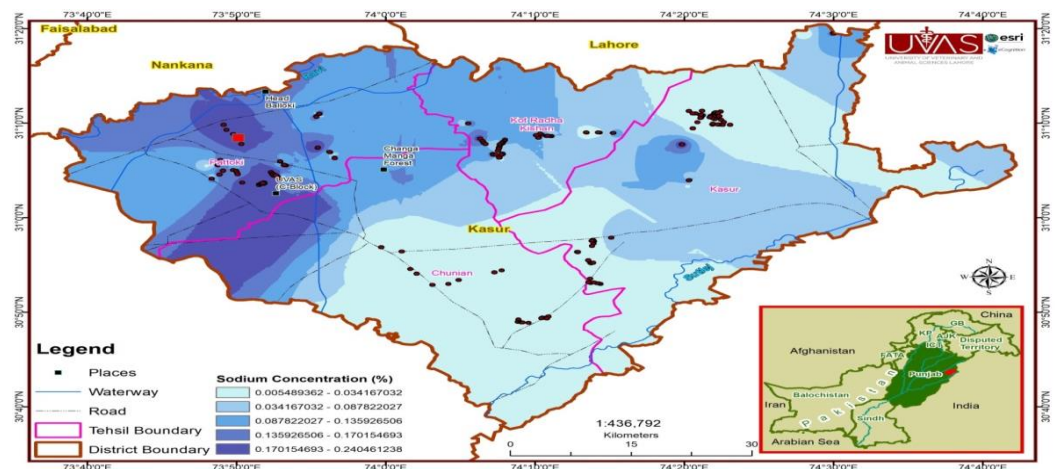


Figure 4. Sodium distribution in different tehsils of district Kasur and its fluctuation.

Forage Potassium

Results of K concentration are given in Table 4. K contents of maize and millet forages were not different ($P > 0.05$) among the all tehsils of the district Kasur. Whereas, K concentration was higher ($P < 0.05$) in the KRK compared with the Kasur in sorghum

forage. Summer forage was low K contents that were documented in NRC (NAC, 2001). K concentrations were below the range as reported by (Khan, 2003; Khan *et al.*, 2007; Khan *et al.*, 2009; Fardous *et al.*, 2010). Forage K+ contents were low with the values observed by (Espinoza *et al.*, 1991) in Florida. K concentrations were also below as reported by (Prabowo *et al.*, 1991) in Indonesia, Ogebe *et al.* (1995) in Nigeria, and (Tiffany *et al.*, 2001) in North Florida. K contents of all forages from all the tehsils of the district Kasur was deficient. Forage K concentration depend upon plant age and detected that young plants have higher K than the mature plants (Tiffany *et al.*, 2001). Different forages have high amount of potassium and livestock get proper quantity of K, deficiency of K would occur if maturity of the forage is increased (McDowell and Valle, 2000). With increase the plant maturity mineral contents decreased due to translocation and natural dilution process through plant root system (McDowell *et al.*, 1983; Pastrana *et al.*, 1991). It may be due to low soil K, plant maturity, leaching of K in large amount to soil (Espinoza *et al.*, 1991) and temperature variation. Forages that were used in this study are summer forages and collected from different locations from different sampling period. Main reason of this fluctuation is pH of that water which is usually for that forages. Soil nature of all tehsil is not similar in all locations. So there is need to feed young forages with K supplementation to livestock daily in diet for their optimum productivity.

Table 4. Potassium concentration (% DM) of selected summer forages in different tehsil's of Kasur District.

Forage	Tehsils of Kasur				S.E.M	P value
	Kasur	K R Kishan	Chunian	Pattoki		
Maize	0.143	0.152	0.146	0.151	0.003	0.693
Sorghum	0.089 ^a	0.120 ^c	0.110 ^{bc}	0.093 ^{ab}	0.003	0.000*
Millet	0.086	0.087	0.089	0.092	0.003	0.809

^{a, c} in a row, means with lower case letters were different significantly at (P<0.05) among tehsils

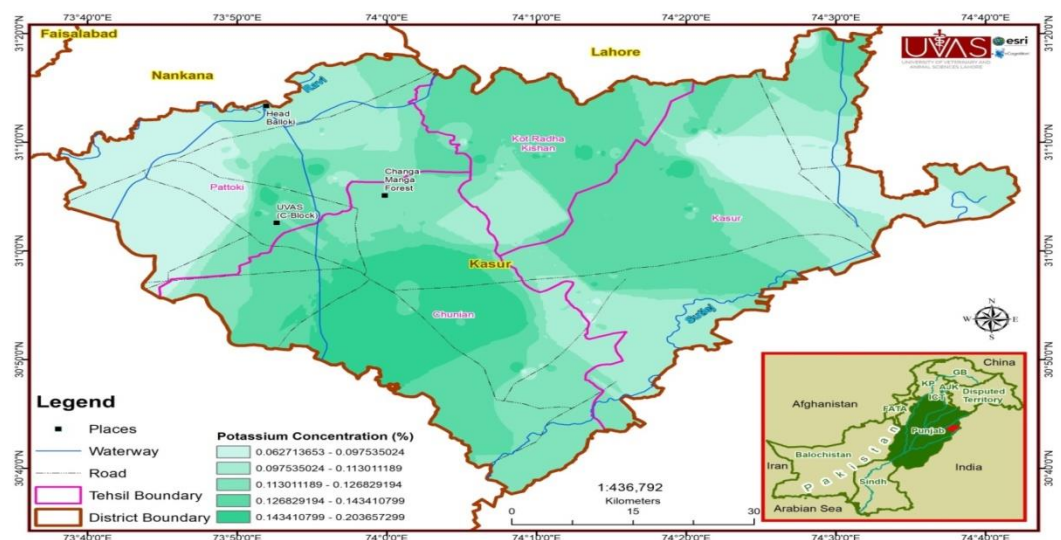


Figure 5. Potassium distribution in different tehsils of district Kasur and its fluctuation.

Conclusion

Concentration of macro mineral was different among four tehsils of district Kasur. Calcium was deficient in Kot Radha Kishan and Chunian; whereas, phosphorus concentration was lower in the summer forages of Chunian and Pattoki tehsils. Sodium was lowest in the Kot Radha Kishan and Pattoki as well as potassium was also lowest in

Kasur. In conclusion, summer forages including maize, sorghum and millet of district Kasur varied had variable concentrations of Ca, P, N and K due to different agronomical practices. Study would provide the base line data that nutritionist to formulate area specific mineral mixtures.

Conflict of Interest

The authors have not declared any conflict of interest.

Authors Contributions

All the authors have contributed equally to the research and compiling the data as well as editing the manuscript.

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