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An evaluation of vertical distribution of available potassium and sulphur by use of different extractants in soils of Dubahar block of Ballia district U.P., India

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Abstract

An investigation was carried out for depth vise distribution of different forms of available potassium and sulphur in soils of Dubahar block of Ballia district was by collection of depth-wise soil samples from two different village's *viz.* Nagava and Dubahar by use of standard method. Soil samples from both villages expess that soil pH ranges from 6.5-7.7, EC 1.001-1.004 dSm^{-1}, organic carbon 0.03-0.40 % and by use of different extractants for available K and S *viz.* NH_4OAc extractable – K 169.2 - 347.2 kg ha^{-1}, 0.01 M $CaCl_2.2H_2O$ extractable – K 78.2 -152.6 kg ha^{-1}, EDTA extractable – K 66.8 -116.6 kg ha^{-1}, water soluble – K 160.2 – 214.0 kg ha^{-1}, HNO_3 extractable – K 186.0 - 288.0 kg ha^{-1}, Mehlich III extractable – K 65.2 -128.0 kg ha^{-1}, and 1 M NaCl extractable – K 95.0 -160.0 kg ha^{-1}, and amount of $CaCl_2$ extractable –S was 5.0 – 6.3 mg kg^{-1}, $NaHCO_3$ extractable – S 4.8 – 5.2 mg kg^{-1}, KCl extractable – S 4.0 - 5.2 mg kg^{-1}, HCl extractable – S 2.3- 3.0 mg kg^{-1}, Morgan's reagent extractable – S was 6.0- 6.8 mg kg^{-1} respectively.

Key words- Extractants, available sulphur, available potassium and soil depth

Introduction

It is well established that potassium is most important major nutrient elements for animal, plant and microbe's growth and development. Soil potassium exists in dynamic equilibrium responsible for quality development in plants and it is present is important four forms viz. water soluble (WSK), exchangeable (Exch–K), non-exchangeable (NEK) and lattice K, of which the first two are important for the growth of higher plants and microbes (Singh *et al.* 2010). A large portion of the total K in soil occurs as structural component of soil minerals and is unavailable to plants. Plants can use only the Exchangeable K present on the surface of soil particles and the K dissolved in soil water release of Exchangeable–K from, non-exchangeable from. The level of soil solution K depends upon equilibrium and kinetic reactions that occur between different forms of K, the soil moisture content and the concentration of bivalent cations in solutions and phase (Sparks and Huang 1985). Sulphur

(S) is another one of the essential nutrient elements for growth and development of all plants. Sulphur (S) is a highly reactive elements present in many forms in soil and is considered as the four major nutrients after nitrogen, phosphorus and zinc for agricultural crop in India (Rathore*et al.* 2015). It is composed of crust with an average concentration of 0.06 %. The sulphur deficiency is widespread in Indian soils and it has been emerging as major limitations increasing crop production and productivity. The common forms of inorganic sulphur in soils are sulphates sulphur, non-sulphate sulphur, adsorbed sulphur, heat soluble sulphur and water soluble sulphur, sulphate -S is present in soil either water soluble or adsorbed forms the latter depends on soil characteristics such as content of iron oxide/hydroxide and pH. Non-exchangeable sulphate sulphur is attributable to primary minerals, pyrites or iron poly sulphides formed as a result of waterlogging, insoluble barium or stronlium salts and Co-crystallized impurities in calcium carbonate. Potassium and sulphur fraction of two soil profile from the two village of Dubahar block would help in management of both nutrient for well cultivation of crop and their quality. Keeping in view of above facts experiment was under taken to study the release of available K and sulphur by different extractant of two village soils of Dubahar lock.

Materials and methods

Geographical position and climatic condition

Ballia district lies between the parallel of 25°23'and 26°11' North latitude and 83° 38' and 84°39' East longitude and 59.2m to 64.92 meter above the sea level. The mean annual rainfall ranges from 950–1150 mm. Study area Dubahar (Nagva and Dubahar village) block lies at 25°45'12" North latitude to 84°12'37" East longitude and 25°45'46" North latitude to 84°15'07" East longitude with an altitude of 72m, above the sea level and Dubahar block 25°45'46" N and 84°15'07" E with longitude of 68 m above the sea level. The district having an area of 1,981square km. The average rainfall is 1608.9 mm. The largest rainfall in 24 hours recorded at any station in the district was 32.0 mm. The average maximum (47.5°c) and minimum (1.6°c) temperature have been recorded in the months of June and January respectively. The relative humidity is generally high during the South west mansoon, being 70%. The relative humidity then starts decreasing the driest part of the afternoon is less then 30%. The average annual wind speed about 4.0 km per hour, and maximum being 7.2 km per hour in May and minimum 1.6 km per hour in November, month.

Selection of site and collection of soil sample -Soil sample where collected from rainfed area of Dubahar block *viz.* Nagva and Dubahar village's soil from the field of well cultivated area. Sampling sites were carefully chosen taking in to consideration the ground cover, micro relief, degree of erosion, surface drainage, proximity to tress and all other factors likely to affect the soil in comparison with the normal type. Soil sample were collected on 26 July, 2019 at the selected site when there were no crops standing in field and no rainfall occurred past 12-24 hours. Before the collection of sample 2 suitable spot (pedon) were dug in the two villages – (Nagva and Dubahar) to collect the soil samples. Nagva village, sampling made from 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105, 105-120 cm depths. About 2 kg of soil from each depth were taken in clean polythene bags separately. Soil sample were collected by the help of khurpi, scale and bucket. After well processing soil sample were ready to analysis of targeted possible parameters in the laboratory of Department of Agricultural Chemistry and Soil Science, S.M.M. Town P.G. College, Ballia. Soil pH was determined with glass electrode Buckman pH meter in 1:2.5 ratio of soil water suspension method described by (Jackson, 1973). EC of the supernatant liquid of the 1:2.5 ratio of soil-water suspension was determined by the conductivity meter method as described by (Jackson, 1973). The organic carbon content of the soil was determined by Walkley's and Black's (1934) rapid titration method as described by Kanwar and Chopra (1998), Ammonium acetate method described by Muhr *et al.* (1965) was used. K fraction by different extractant as Calcium Chloride Extractable K method described by Woodruff and McIntosh (1960), EDTA Extractable K by Haynes and Swift (1983), Water Soluble K by Rouse and Bertramson (1949), Nitric Acid (HNO_3) Extractable K by Wood and Deturk (1940), Mehlich-III Extractable K by Mehlich (1984), $CaCl_2$ extractable-sulphur Williams and Steinberg (1969), Morgan's reagent extractable Sulphur by Chesnin and Yien (1951), 0.5 M $NaHCO_3$ extractable sulphur by Kilmer and Nearpaoo (1996) and Singh and Srivastava (1993), KCl extractable Sulphur by Bloem*et al*. (2002), HCl extractable Sulphur-by Little *et al*. (1958) was used.

Results and discussion

Soil pH

Soil pH (table -1) value from two different pedon of two village Nagva and Dubahar block soil of soils on 0-15, 15-30, 30-45, 45-60, 60-75, 75-90, 90-105, 105-120 cm of soil ranged from 6.5 to 7.7 . The increasing range of pH towards slightly saline for surface soil (0-15) to lower depth (135-150 cm). Pedon – 1 was showed 7.1 pH at 0-15 cm decrease with depth up to 6.5 (135-150 cm). Pedon -2 (table-1) pH range from 6.4 at 0-30 cm and it was increasing up to 105-120 cm value 7.7. The lower pH range was found at upper layer of Dubahar village soil than the 105-120 cm depth of soil due to presence of organic matter and possible higher activity of hydroxyl aluminum at higher pH level resulted in higher P adsorption (Mokwanye, 1975)

Table 1: pH, EC and organic carbon content in different depth (cm) of Dubahar and Nagva village soil of Dubahar block

Depth (cm)	Dubahar			Nagawa		
	pH	EC (dSm^{-1})	Organic carbon (%)	pH	EC (dSm^{-1})	Organic carbon (%)
0 – 15	7.1	1.003	0.92	6.4	0.995	0.73
15 – 30	7.4	1.001	0.80	6.7	0.996	0.65
30 – 45	7.3	1.002	0.64	7.3	1.002	0.54
45 – 60	7.2	1.004	0.51	6.6	0.998	0.66
60 – 75	6.5	0.996	0.58	6.8	0.9977	0.63
75 – 90	7.1	1.002	0.50	7.3	1.002	0.57
90 – 105	7.4	1.003	0.41	6.5	0.996	0.61
105 – 120	7.5	1.006	0.41	7.7	1.006	0.26

Electrical conductivity of soil (EC)

Soil EC in table–1 of both village Nagva and Dubahar block soils pedons depth on 0-15, 15-30, 30-45,45-60, 60-75,75-90, 90-105,105-120 cm resultedtheir ranged from 1.006 to 0.887 dSm^{-1} in both pedon. Pedon-1 was showed 1.003 dSm^{-1} at 0-15 cm and 0.995 dSm^{-1} at 135-150 cm depth. Pedon-2 soil EC range from 0.995 dSm^{-1} at 0-30 cm and 1.006 dSm^{-1}. Electrical conductivity varied between 1.006 to 0.887 dSm^{-1} characteristics of the black alluviate soil.

Organic carbon (%)

Value in table-1 of two different pedon of both village Nagva and Dubahar block soil on 0-15, 15-30, 30-45,45-60 60-75,75-90, 90-105,105-120 cm. Pedon–1 soil was contained maximum organic carbon content 0.92 % in surface soil 0-15 cm to 0.25 % in sub-surface soil . Pedon-2 soil was showed 0.73% organic carbon value at 0-30 cm after that it was increase 0.26 % organic carbon content was seen. Both pedon were showed high to low range of organic carbon content. Therefore surface soil contained greater amount of organic carbon then the lower depth soil might be due to accumulation of organic materials on surface.

Vertical distribution of available Sulphur of Nagva Village soil of Dubahar Block

The amount of $CaCl_2$ extractable – S, 0.5 $NaHCO_3$ extractable – S, KCl extractable – S, HCl extractable – S and Morgan'sreagent extractable – S at pedon– 1 in 0-15, 15-30, 30-45,45-60 60-75,75-90, 90-105,105-120 cm soil depth (Table – 2) $CaCl_2$ extractable – S, was decreased with increase in horizon soil depth Pedon-1 similarly, 0.5 $NaHCo_3$ extractable – S, HCl extractable – S, KCl extractable – S and Morgan's reagent extractable– S were also decreased with increase in depth. But, slightly increase at further depth. In pedon -1 $CaCl_2$ extractable – S was measured 11.25 mg/kg at 0-15 cm soil depth 6.25 mg/kg at 105-120 cm depth, 0.5$NaHCo_3$ extractable – S was measured 11.25 mg/kg at 0-15 cm soil depth to 3.25 mg/kg at 105-120 cm depth, KCl extractable – S was measured 10 mg/kg at 0-15 cm soil depth to 1.75 mg/kg at 105-150 cm depth, HCl extractable – S was measured 1.375 mg /kg at 0-15 cm soil depth to 6.25 mg/kg at 135-120 cm depth on surface horizon. The similar finding have been given by Misal *et al.* (2017) and Azim *et al.* (2018).

Table 2: Distribution of Sulphurforms (ppm) in different depth of Nagva village soil of Dubahar block

Depth (cm)	$CaCl_2$ Extractable – S	$NaHCO_3$ Extractable – S	KCl Extractable - S	HCl Extractable – S	Morgan's reagent Extractable - S
0 – 15	11.25	11.25	11.25	10	11.25
15 – 30	10	11.25	10.25	8.75	10
30 – 45	8.75	10	8.75	7.5	8.75
45 – 60	8.75	8.75	7.5	7.5	8.72
60 – 75	7.5	7.5	6.25	5	7.5
75 – 90	7.5	6.25	5	3.75	6.25
90 – 105	6.25	6.25	2.5	3.72	5
105 – 120	6.25	3.75	1.75	2.5	3.75

Vertical Distribution of availabe Sulphur in Dubahar Village soil of Dubahar block

The amount of $CaCl_2$ extractable – S, 0.5 $NaHCO_3$ extractable – S, HCl extractable – S and Morgan's reagent extractable – S were measured at pedon–2 in 0-15, 15-30, 30-45,45-60 60-75,75-90, 90-105,105-120 cm soil depth (Table – 3). $CaCl_2$ extractable – S was decreased with increase in horizons soil depth. Pedon-2 similarly, 0.5$NaHCO_3$ extractable–S, HCl extractable – S, KCl extractable – S and Morgan's reagent extractable – S were also decreased with increase in depth. But, slightly increase at further depth. In pedon-2 $CaCl_2$ extractable – S, was measured 7.5 mg/kg at 0-30cm, soil depth to 1.25 mg/kg at 105-120 on surface horizon, 0.5 $NaHCO_3$ extractable – S was measured 11.25 mg/kg 0-15cm, soil depth to 1.25 mg/kg at 105- 120 in surface horizon, KCl extractable – S was measured 11.5 mg/kg at 0-15 cm, soil depth to 1.25 mg/kg at 105-120 in surface horizon, HCl extractable – S was measured 11.25 mg/kg at 0-15 cm, soil depth to 1.625 mg/kg at 105-120 in surface horizon and Morgan's reagent extractable – S was measured 10 mg/kg at 0-30, soil depth to

1.25 mg/kg at 105-120 in surface horizons. The similar finding have been given by Misal *et al.* (2017), Singh *et al.* (2019) and Azim *et al*. (2018) also.

Table 3. Distribution of Sulphur forms (ppm) in different depth of Dubahar village Soil of Dubahar block

Depth (cm)	$CaCl_2$ Extractable – S	$NaHCO_3$ Extractable – S	KCl Extractable - S	HCl Extractable – S	Morgan's reagent Extractable – S
0 – 15	7.5	11.25	11.25	11.25	10
15 – 30	7.5	8.75	7.5	10	8.75
30 – 45	6.25	7.5	6.25	8.75	7.5
45 – 60	5	6.25	3.75	6.25	6.25
60 – 75	3.75	5	2.5	3.75	3.75
75 – 90	2.5	3.75	1.75	2.5	2.5
90 – 105	1.75	2.5	1.25	1.75	1.75
105 – 120	1.25	1.25	1.5	1.625	1.25

Vertical distribution of forms of potassium (kg/ha) in Nagva village soil of Dubahar block

The amount of NH_4OAc extractable – K, 0.01M $CaCl_2$. $2H_2O$ extractable – K, HNO_3 extractable were measured in Pedon – 1 at 0-15, 15-30, 30-45,45-60 60-75,75-90, 90-105,105-120 cm horizons depth (Table-4). Available potassium was decreased with increased in horizons depth at Pedon – 1, similarly, 0.01M $CaCl_2$ extractable K were also decreased with increase in depth. But, EDTA extractable – K, Water soluble- K were indicating increasing trend with increase in depth at pedon– 1. Available potassium was measured 548.0 kg/ha at 0-15 cm soil depth to 336.0 kg/ha at 105-120 cm depth on surface horizon, 0.01M $CaCl_2$ extractable K, 246.4 kg/ha in 0-15 cm soil depth to 136.8 kg/ha at 105-120 cm in surface horizon, EDTA extractable – K, 433.2 kg/ha in 0-15 cm soil depth to 342 kg/ha at 105-120 cm in surface horizon, Water soluble K, 295.2 kg/ha in 0-15 cm soil depth to 148.4 kg/ha

Table 4. Distribution of potassium (kg/ha) forms in different depth of Nagva village of Dubahar block

Depth (cm)	NH_4OAc Extractable – K	0.01 M $CaCl_2$.2 H_2O Extractable – K	EDTA Extractable - K	Water Extractable - K	HNO_3 Extractable – K
0 – 15	548.0	246.4	433.2	295.2	478.8
15 – 30	492.8	228	421.8	262.2	467.4
30 – 45	470.4	216.6	410.4	250.8	456
45 – 60	469.2	182.4	399	228	444.6
60 – 75	448	171	376.2	205.2	433.2
75 – 90	436.8	159.6	364.8	182.4	421.8
90 –105	414.4	136.8	353.4	159.6	410.4
105- 120	336	136.8	342	148.4	387.6

at 105 – 120 cm in surface horizons, HNO_3 extractable K, 478.8 kg/ha 0-15 cm soil depth to 387.6 kg/ha at 105-120 cm in surface horizons. So that surface soil contain greater amount of NH_4OAcK then the other extractants, the similar finding have been given by Anupama *et al.* (2018), Singh *et al*. (2019) and Mali *et al.* (2016) also.

Vertical distribution of forms of potassium (kg/ha) in Dubahar village

The amount of NH_4OAc extractable – K, 0.01M $CaCl_2$ extractable K, EDTA extractable K, HNO_3 extractable K and Mechlich – III extractable K were measured at Pedon – 2 in 0-15, 15-30, 30-45,45-60 60-75,75-90, 90-105,105-120 cm (Table 5). NH_4OAc was decreased with increase in horizons depth at pedon – 2 Similarly, 0.01M $CaCl_2$ extractable K, HNO_3 extractable K, and Mechlich – III were also decreased with increase in horizons depth, But EDTA extractable K and Mechlich – III extractable K, decreased with increase in depth but slightly increase at further depth. In Pedon – 2. NH_4OAc K, was measured 369.6 kg/ha at 0-30 cm soil depth to 324.8 kg /ha at 105-120 cm on surface horizons, 0.01M $CaCl_2$ extractable K, 387.6 kg/ha at 0-15 cm soil depth to 330.6 kg/ha at 105-120 cm in surface horizons, EDTA extractable K, 513 kg/ha 0-135cm soil depth to 313.6 kg/ha at 105-120 cm in surface horizons, water soluble K, 285.2 kg/ha 0-15 cm soil depth to 146.4 kg/ha at 105-120 cm in surface horizons, HNO_3 extractable K, 387.6 kg/ha at 0-15 cm soil depth to 250.8 kg/ha at 105-120 cm in surface horizons and Mechlich – III extractable K, 421.8 kg/ha at 0-15 cm soil depth to 205.2 kg/ha at 105-120 cm in surface horizons. Therefore, NH_4OAcextractant have been appeared to release greater amount of K then the other extractants it might be due to solubility effect, the similar finding have been given by Anupama *et al.* (2018) and Mali *et al*. (2016) also.

Table 5. Dstribution of potassium forms (kg/ha) in different depth of Dubahar village of Dubahar block

Depth (cm)	NH_4OAc Extractable – K	0.01 M $CaCl_2.2H_2O$ Extractable – K	EDTA Extractable – K	Water Extractable - K	HNO_3 Extractable - K	Mehlich III Extractable – K
0 – 15	369.6	387.6	513	285	387.6	421.8
15 – 30	365.6	376.2	467.4	262.2	353.4	376.2
30 – 45	358.4	364.8	421.8	220.3	342	364.8
45 – 60	356.4	362.8	410.4	185.2	330.6	330.6
60 – 75	347.2	353.4	403.2	172.8	307.8	273.6
75 – 90	342.2	350.4	364.8	168	296.4	262.2
90 –105	336	342	342	148.4	273.6	250.8
105- 120	324.8	330.6	313.6	146.4	250.8	205.2

Conclusion

The use of different extractant to release of available potassium and sulphur in soil of Nagawa and Dubahar village of Dubahar block block showed that maximum release of available K by neutral NH_4OAc extractant among the extractants in both pedon while maximum amount of available S was found by $CaCl_2$ extractant among the extractants.

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