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Determination of the Concentration of Nutrients Limiting Wheat Production in Ololulunga in Narok County, Kenya

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Abstract

The drive for targeting higher agricultural production needs a balanced use of nutrients which otherwise create problems of soil fertility exhaustion and nutrient imbalances. The current research sampled 15 farms from Ololulunga, Narok County to determine the levels of nitrate, phosphate and sulfate using UV-VIS and data analyzed using MSTAT-C, SPSS and student t-test. The nitrate concentration varied from 32.441mg/kg to 11.108mg/kg before planting and 36.759mg/kg to 21.646mg/kg after planting. The phosphate concentration varied from 3.001mg/kg to 0.368mg/kg before planting and 9.508 mg/kg to 2.357mg/kg after planting. The sulfates concentration varied from 6.678mg/kg to 3.661mg/kg before planting and 8.028 mg/kg to 4.111 mg/kg after planting. Generally, it was observed that almost all farms had different application rates of these nutrients and maybe this depended on the financial ability of individual farmer. It was found that nitrate had the least CV% of 6.71, sulfates, 8.54% and phosphates 40.88 % and the nutrients before and after planting were significant ($p < 0.05$).

Keywords: Nitrate, sulfate, phosphate, UV-VIS, soil.

Introduction

Soil is a diverse complex that can be defined as a mixture of minerals and organic materials which are capable of supporting life[1, 2]. Soil fertility status of the soils of an area is used for soil characterization and this is an important aspect in context of sustainable agriculture production.[3] The drive for targeting higher agricultural production needs a balanced use of nutrients which otherwise create problems of soil fertility exhaustion and nutrient imbalances not only of macronutrients but also of micronutrients[4]. Soil fertility is one of the most important factors controlling yields of the crops and good productivity of soil depends upon availability of essential nutrients in the soil to the plant[3,5]. Phosphorous and nitrogen are required in fairly large amounts while sulfur is a secondary nutrient which is required by plants in small amounts and are important for health plant growth as compared to the primary nutrients[6,7]. Nitrogen plays an important role in carbohydrates utilization and phosphorous in energy transformation[8]. High phosphorous concentration can promote the growth of biota and may cause problems of biological oxygen demand for aquatic life. The causes of nutrient depletion include farming without replenishing nutrients over time, leaching due to inadequate run off management, removal of crop residue, low level of fertilizer use and unbalanced application of nutrients[9]. In terms of its requirements and management in the field, nitrogen is the most important nutrient for all crops and its availability is closely related with plant productivity[10-12]. Plants take up nitrogen in the form of ammonium (NH_4-N) and nitrates (NO_3-N) but nitrate is the dominant of mineral nitrogen available for plants use[13, 14]. The present study was carried out to determine the available phosphates, nitrates and sulfates in Ololulunga wheat growing are to determine whether the macro nutrient were sufficient in the various farms.

Study Area: Ololulunga in Narok is situated in the southern part of the Rift valley of Kenya and borders north of Tanzania. Its geographical co-ordinates are 1° 5' 0" south and 35° 52' 0" East with an altitude of 1827 (5,997 feet) above sea level. The socio-economic activities in this area are majorly large scale wheat farming and free animals ranching.

Material and Methods

The regents used were all of analytical grade and these included nitric acid, sulfuric acid, hydrochloric acid, absolute ethanol, sodium chloride, glycerol, barium chloride, phenol, phenol disulphonic acid, para-nitrophenol indicator, vanadomolybdate and ammonia solution. The equipment used was UV-VIS Shimadzu 1240.

Soil sampling: Soil samples were collected from Ololulunga area using stratified randomized complete block design with three replications from various wheat farms before the planting period and after planting. The control sample was picked from an area where farming has never been done. The soil samples were sampled from a depth of 0 to 15cm and were put into plastic bags and were transported to Maasai Mara University and JKUAT laboratories where they were air dried and stored in plastic bags ready for analysis.

Analysis of nitrates in the soil samples: A digestion mixture was prepared by making a mixture of 25g of phenol in 250 mL concentrated sulphuric acid. A 1g of soil sample was weighed and put in a glass conical flask and then 50 mL of the digestion mixture was added and the contents were left to stand for 6hours. Then 25mL of the digest was placed in crucible and evaporated to dryness on a hotplate. A volume of 3mL of phenol disulphonic acid was added and swirled gently and left to stand for 10minutes then 15mL of distilled water was added and stirred with a glass rod. And on cooling 3 drops of para nitro-phenol indicator was added and ammonia solution added until intense yellow color was observed. The sample volume was then topped to 100mL and left to stand for 30 minutes and measurement was done at 420nm in a UV-VIS.

Analysis of phosphates in the soil samples: 1g of each of the soil samples was weighed and placed in conical flasks, and then 50mLs of the diacid (HCl and HNO_3 in the ratio of 3:1) was added and shaken for 30 minutes in the mechanical shaker, and left to stand for 6 hours to allow complete digestion. The contents were then filtered using a porous whatman filter paper no 42. 10 mL of the filtered sample was then placed in a boiling tube and 3 drops of the nitro-phenol indicator was added. 6N ammonia solution was then added and decolorized using 1N HNO_3 and 5mL of vanadomolybdate. The volume was made up to 50 mL in a volumetric flasks using distilled water. The concentration of the samples was then read after 30 minutes at 400 nm using a UV-VIS.

Analysis of Sulfates in the soil samples: A 1g of the air dried soil sample was measured and put in plastic bottles and 100 mL of distilled water was added then the contents were shaken for 1 hour in a mechanical shaker. A volume of 50 mL of the sample was put into 250 volumetric flask and topped up to the mark. The sample was then diluted 50 times and a volume of 5mL of the conditioning agent (30mL HCL, 100mL ethanol, 75g NaCl and 50mL glycerol) was added followed by 5 mL $BaCl_2$ solution and a measurement was read at 420 nm using a UV-VIS.

Results and Discussion

Before planting, the sample with the highest concentration of nitrates was sample 10 with a mean concentration of 32.441 ± 0.052 mg/Kg and the lowest concentration was sample-7 with a mean concentration 11.108 ± 0.002 mg/Kg. After planting the highest concentration of nitrates was found in sample 10 with a mean concentration of 36.759 ± 0.006 mg/Kg and the lowest concentration was found in sample 6 with a mean concentration of 21.646 ± 0.005 mg/Kg. The whole study area had a mean concentration of 18.421 ± 4.969 mg/Kg before planting and 26.170 ± 4.297 mg/Kg after planting while a control sample had a concentration of 35.147 ± 0.078 mg/Kg which was higher than all samples from the study area for the two seasons except for sample 10 which had a mean concentration of 36.759 ± 0.006 mg/kg after planting. This can probably be due to depletion of nitrates as the tilling continues without replenishing of the nitrates over the years. The coefficient of variation for nitrate in all the farms for the two seasons was 6.71% indicating that the mean concentrations of nitrate in all farms were not different. This could be attributed to the fact that the farmers applied the nitrates in the some ratio as recommended by the agricultural extension officer in the area. The mean difference in nitrate concentration before and after planting was significant ($P<0.05$).

Table -1
Table showing concentration of Nitrates, Phosphate and Sulfate

	Nitrate		Phosphate		Sulfate	
Sample	Before	After	Before	After	Before	After
1	16.928±0.002	22.348±0.001	0.429±0.007	4.938±0.032	6.393±0.006	7.361±0.015
2	17.350±0.005	26.110±0.000	0.839±0.001	3.421±0.018	6.678±0.000	7.453±0.051
3	14.657±0.001	23.204±0.004	3.001±0.006	9.508±0.006	4.913±0.003	5.221±0.011
4	19.024±0.023	24.417±0.004	1.138±0.004	4.010±0.008	6.007±0.012	6.017±0.000
5	16.733±0.003	26.424±0.006	2.077±0.006	2.958±0.001	3.661±0.016	4.111±0.000
6	14.853±0.010	21.646±0.005	0.930±0.016	2.357±0.105	5.040±0.059	6.944±0.000
7	11.108±0.002	22.555±0.006	1.035±0.001	5.917±0.008	5.005±0.000	6.301±0.000
8	20.955±0.039	26.309±0.002	0.368±0.005	4.008±0.006	5.538±0.011	8.028±0.000
9	24.088±0.008	33.314±0.001	2.642±0.028	6.526±0.006	5.157±0.029	6.051±0.000
10	32.441±0.052	36.759±0.006	1.058±0.010	5.028±0.006	5.293±0.000	6.700±0.019
11	16.111±0.003	23.459±0.017	0.627±0.016	3.128±0.006	5.480±0.011	7.272±0.000
12	17.065±0.012	25.566±0.006	1.686±0.011	4.017±0.005	4.408±0.013	6.515±0.000
13	15.189±0.001	24.423±0.004	0.429±0.007	7.073±0.001	5.388±0.021	6.366±0.058
14	19.039±0.005	25.034±0.003	0.484±0.010	3.530±0.008	4.994±0.003	6.299±0.001
15	20.777±0.011	30.973±0.005	0.547±0.002	6.432±0.009	4.022±0.001	5.842±0.000

Before planting, the nitrate mean concentration for Ololulunga area was 18.421 ± 4.969 mg/Kg and this whole area was therefore found to be deficient in nitrate since the concentration was below 20 mg/Kg hence there is need for nitrate to be added before planting[15]. After planting the nitrates concentration was found to have increased to 26.170 ± 4.297 mg/Kg and therefore the area had sufficient nitrate since the concentration was between 20mg/Kg and 24mg/Kg but the nitrogen based fertilizers can still be added to these farms[15]. Nitrate concentrations in all the sampled areas were within WHO acceptable limits[16]. Before and after planting all the sampled areas in this study except one had a nitrate concentration above 15mg/Kg but there is need to add more nitrate based fertilizer to these farms in order to experience good yields as the critical level is 15mg/kg[17].

Before planting, the sample with the highest concentration of phosphate was found in sample 3 with a mean concentration of 3.001 ± 0.006 mg/Kg and the lowest concentration was found in sample 8 with a mean concentration 0.368 ± 0.005 mg/Kg. After planting the highest concentration was found in sample 3 with a mean concentration of 9.508 ± 0.006 mg/Kg and the lowest concentration was found in sample 6 with a mean concentration of 2.357 ± 0.105 mg/Kg. The whole study area had a mean concentration of 1.153 ± 0.823 mg/Kg before planting and 4.857 ± 1.923 mg/Kg after planting while a control sample had a concentration of 1.594 ± 0.000 mg/Kg which is lower than all samples from the study area after planting and only four sample before planting having a concentration above the control. This can be probably due to continuous addition of phosphate fertilizers to the soil every season hence accumulation of phosphates in the soil.

The coefficient of variation for phosphate in all the farms for the two seasons was 40.88% indicating that the mean concentrations of nitrate in all farms were quite different. This could be attributed to the fact that the farmers applied the nitrates in the different ratios. Mean difference in phosphate concentration before and after planting was significant ($P<0.05$) There was lower phosphate concentration before planting than there was after planting.

The concentrations of phosphate in this study were found to be lower than that obtained in a study done in the soils of south Surma and Jalalpur of 6.6 mg/Kg and 5.9 mg/Kg respectively[18]. Ten samples in this study were found to be within WHO acceptable limits with the rest being way above it before planting and all the samples after planting exceeded the limits[16]. The range found in this study agrees with that done in the soils of western Kenya but the concentration were lower before planting[19]. All the sampled areas before and after planting had a phosphate concentration below the critical levels of soil phosphate[17,20]. All the sampled areas before planting were phosphate deficient since the concentration was below 5mg/Kg and only six farms after planting had sufficient phosphate concentration[21,22]. The sampled farms of Ololulunga can therefore be generally be classified as phosphate deficient. Before planting, the sample with the highest concentration of sulfates was found in sample 2 with a mean concentration of 6.678 ± 0.032 mg/Kg and the lowest concentration was found in sample 5 with a mean concentration 3.661 ± 0.016 mg/Kg. After planting the highest concentration was found in sample 8 with a mean concentration of 8.028 ± 0.000 mg/Kg and the lowest concentration was found in sample 4 with a mean concentration of 6.017 ± 0.000 mg/Kg. The whole study area had a mean concentration of 5.199 ± 0.805 mg/Kg before planting and 6.432 ± 0.966 mg/Kg after planting while a control sample had a concentration of 2.939 ± 0.053 mg/Kg which is lower than all samples from the study area for the two seasons. This can probably be due to continuous addition of sulfates as the tilling continues in the area of study.

The coefficient of variation for sulfates in all the farms for the two seasons was 8.54% indicating that the mean concentrations of sulfate in all farms were not different. This could be attributed to the fact that the farms applied the sulfates in the some ratio as recommended by the agricultural extension officer. The mean difference in sulfates concentration before and after planting was significant ($P<0.05$). There was lower sulfate concentration before planting than there was after planting an indication that sulfate was added during planting.

Sulfates concentration, in all the sampled areas before and after planting were much below WHO acceptable limits of 200mg/Kg[16]. All the sampled areas in this study before planting were sulfate deficient since the concentration was below 6mg/Kg and only two samples had a moderate concentration of between 6mg/Kg and 12mg/Kg[23]. After planting all the samples had a moderate concentration of sulfates except two samples which were sulfate deficient. The sampled areas in the two seasons had deficient in sulphate since they had a concentration below the critical levels[20-22]. The sampled farms can therefore be reported as sulfate deficient hence the farmers of Ololulunga will be required to add more sulfur based fertilizers to their farms to experience good yields.

The dendrogram shows concentrations of nitrate, phosphates and sulfate in the sampled farms. The farms can majorly be grouped into several groups with the first group having three farms, the second and the third group having four farms each and the rest having one farm each. This might be an indication that the farmers in these areas applied the fertilizers in the different ways depending on their financial capabilities or they applied different types of fertilizers. Farm three was completely dissimilar from all other farm in terms of the nutrients concentration and this could be attributed to different applications rates or application of different types of fertilizer as compared to other farms.

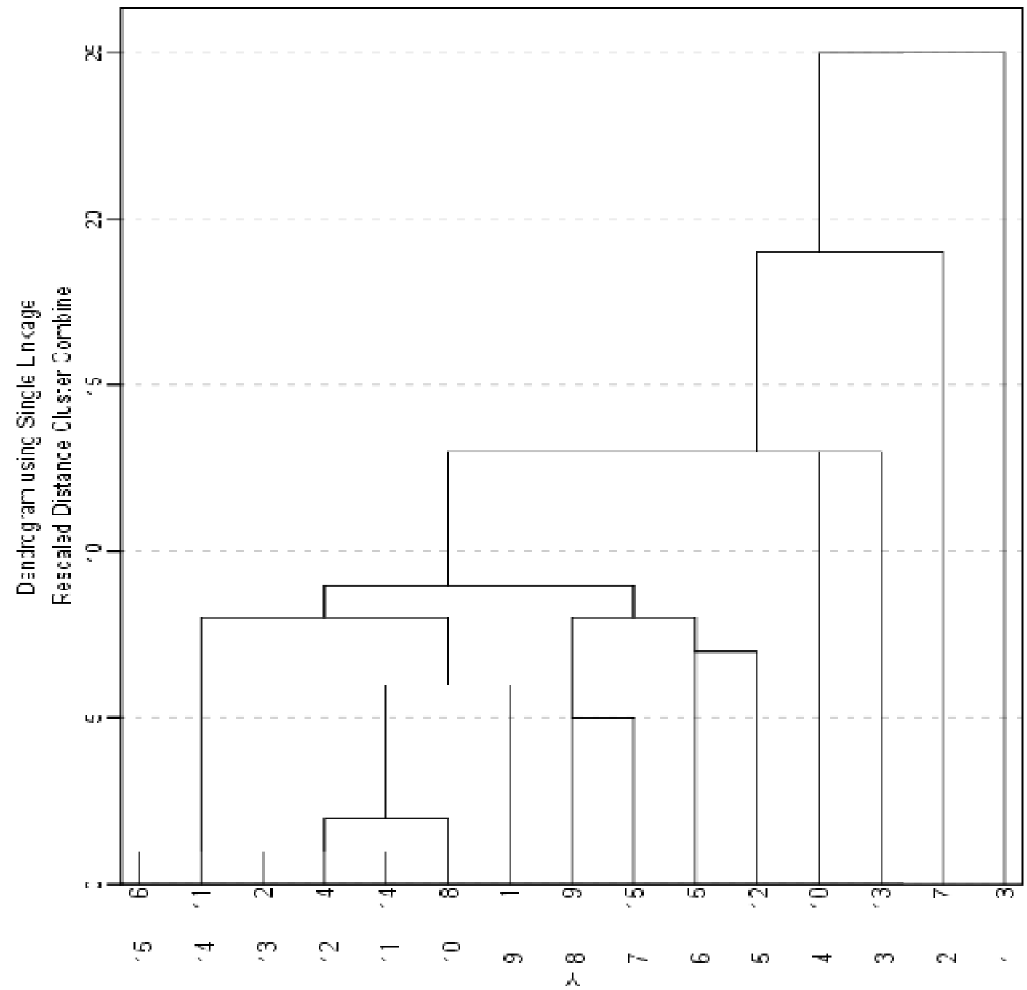

Figure-1
Dendrogram showing the variation of the nutrients in the various farms

Conclusion

The nitrate concentration varied from 32.441mg/kg to 11.108mg/kg before planting and 36.759mg/kg to 21.646mg/kg after planting. Most of farms needed addition of nitrates before planting and even after planting. Comparing the control concentration it was deduced that planting has depleted the amount of nitrates in the wheat growing farms. The phosphate concentration varied from 3.001mg/kg to 0.368mg/kg before planting and 9.508 mg/kg to 2.357mg/kg after planting. Most of farms needed addition of phosphates before planting and even after planting and was noted that source of phosphates was through the addition of fertilizer since the control had a concentration of 1.594mg/kg. The sulfates concentration varied from 6.678mg/kg to 3.661mg/kg before planting and 8.028 mg/kg to 4.111 mg/kg after planting. Most of the farms had accumulated the sulfate concentrations overtime due addition of fertilizer since the control had low concentration of 2.939mg/kg. Generally, it was observed that almost all farms had different application rates of these nutrients and maybe this depended on the ability of individual farmers financially.

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