Available online at www.jobpcr.com

ISSN-2394:3076
CODEN(USA) : JBPCBK

Journal of Biological Pharmaceutical And Chemical Research , 2016,3(1): 4-12

(http://www.jobpcr.com/arhcive.php)

Assessment of Relationship between Soil Organic Matter and Macronutrients, Western Nepal

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ABSTRACT

*Soil organic matter is an important soil chemical parameter influencing soil sustainability. Revealing this factor, the study was conducted to determine relationship between soil organic matter and total nitrogen, available phosphorus, extractable potassium, calcium and magnesium, and available sulphur. The total 172 soil samples were collected from the three sites of western region at 0-20 cm depth. The collected samples were analyzed by standard method in Soil Science Division, Khumaltar. To compute the relationship between soil organic matter and the macronutrients, simple linear correlation and regression were preformed. The result revealed soil organic matter was significantly and positively correlated with primary nutrients namely; total N (r=.73**).), available P_2O_5 (r=.57**) and extractable K_2O (r=.35**). While, there was significant and negative correlation between with secondary nutrients as extractable Ca (r=.29**), Mg (r=.33**) and available S (r=.19**). In addition, with the increase on organic matter by one unit, total N, available P_2O_5 and extractable K_2O increases by 0.038, 31.19 and 5.92 units, respectively and vice-versa. Whereas, extractable Ca, Mg and available S decreases by 87.75, 13.39 and 0.37 units, respectively and vice-versa. Therefore, maintenance of optimal soil organic matter is essential to make macronutrients concentration balanced in western Nepal.*

Key words: Correlation, Macronutrients, Regression, Soil organic matter.

INTRODUCTION

Soil, being the top layer of the earth's crust that performs many vital functions such as food and biomass production, storage, filtration and transformation of many macro and micro nutrients (Kaur *et al.*, 2014). It is important not only for agriculture but also have more useful for all living organisms of universe.

The six elements nitrogen, phosphorous, potassium, calcium, magnesium and sulphur which are required in large quantities are labeled as macronutrients (Havlin *et al.*, 2010). Most of the soils supply enough calcium, magnesium and sulphur and hence, these elements are called as secondary nutrient element. The other three elements nitrogen, phosphorous and potassium are called as primary nutrients and are not usually available in large amounts which is adequate for best growth and therefore are added through fertilization.

Soil organic matter consists of a wide range of organic substances, including living organisms, carbonaceous remain of organisms that once occupied the soil, and organic compounds produced by current and past metabolism in the soil. It is a major soil source of the plant nutrients phosphorus and sulphur, and the primary source of nitrogen for most plants. As soil organic matter decays, these nutrients elements, which are present in organic combinations, are released as soluble ions that can be taken up by plant roots (Brady and Weil, 2004).

Plants take their nutrients mostly from soil. It is well known that the optimum plant growth and crop yield depends not only on the total amount of nutrients present in the soil at a particular time but also on their availability which in turn is controlled by physico-chemical properties like: soil texture, organic carbon, calcium carbonate, Cation exchange capacity, pH and electrical conductivity of soil (Bell and Dell, 2008).

Understanding of soil chemical reaction and processes is essential for developing innovative resource management strategies, and understanding and regulating the behavior of the terrestrial ecosystem at regional and global scale. Therefore, a comprehensive study was undertaken to know the relationship between soil organic matter and macronutrients collected from the three selected sites of western Nepal.

MATERIALS AND METHOD

Study area

The study was done in the three sites of western Nepal. The three sites were Regional Agricultural Research Station, Lumle, Kaski; Horticulture Research Station, Malepatan, Kaski and National Wheat Research Program, Bhairahawa, Rupandehi (Figure1). The Regional Agricultural Research Station, Lumle is situated at the latitude 28°17’51.89’’N and longitude 83°49’2.87’’E as well altitude 1750 m above sea level. The Horticulture Research Station, Malepatan is geographically situated at the latitude 28º13’07”N and longitude 83º58’21”E as well altitude 850 m above sea level. The National Wheat Research Program, Bhairahawa is geographically situated at the latitude 27º31’49”N and longitude 83º27’36”E as well altitude 82 m above sea level.

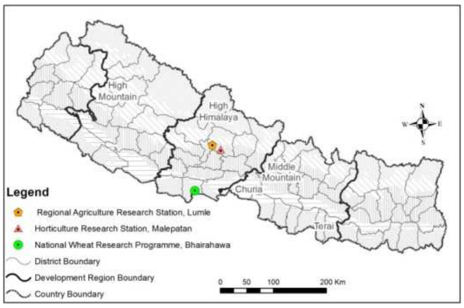

Figure 1. Locations map for the study area of western Nepal

Collection of soil samples

The total one hundred seventy two (172) soil samples were collected randomly at 0-20 cm depth during 2014. The sampling points were determined based on the variability of the land on each site.

Laboratory analysis

The collected samples were dried at room temperature and ground in powdered form and analyzed in the laboratory for the determination of required chemical properties at Soil Science Division, Khumaltar. The different methods adopted for chemical properties determinations are listed in the table 1.

Table 1. Methods adopted for the laboratory analysis at Soil Science Division, Khumaltar

S.N.	Parameters	Methods
1.	Chemical	
1.1	Organic matter %	Walkely and Black (Walkely and Black, 1934)
1.2	Micro-nutrients	
1.2.1	Total N %	Kjeldahl (Bremner and Mulvaney, 1982)
1.2.2	Available P_2O_5 ppm	Olsen's (Olsen *et al.*, 1954)
1.2.3	Extractable K_2O ppm	Ammonium acetate (Jackson, 1967)
1.2.4	Extractable Ca ppm	EDTA Titration (El Mahi, *et.al.*,1987)
1.2.5	Extractable Mg ppm	EDTA Titration (El Mahi, *et.al.*,1987)
1.2.6	Available S ppm	Turbidimetric (Verma,, 1977)

Statistical analysis

Correlation and regression analyses were carried out to detect functional relationship between soil organic matter and macronutrients. The data analyses were done using a statistical software package SPSS 16.0 and Microsoft Office Excel 2007.

RESULT AND DISCUSSION

The results relating relationship between soil organic matter and macronutrients is shown on the table (2-3) and figure (2-7).

Table 2. Summary statistics of the studied soil samples

Parameters	Mean*	Standard Deviation	Standard Error	Minimum	Maximum
Organic matter %	3.40	2.20	0.15	0.5	12.86
Total N %	0.20	0.13	0.01	0.04	0.49
Available P_2O_5 ppm	101.68	120.01	7.91	2.68	531.15
Extractable K_2O ppm	56.09	37.60	2.48	5.81	237.38
Extractable Ca ppm	883.53	711.03	54.22	20	3580
Extractable Mg ppm	102.97	97.32	7.42	12.1	580.8
Available S ppm	6.58	4.64	0.35	0.5	25.5

*Mean of one hundred seventy two samples

Table 3. Correlation coefficient (r) of macronutrients with organic matter on the studied soil samples

Micronutrients	r	P value	n
Total N %	.73**	<0.001	172
Available P_2O_5 ppm	.57**	<0.001	172
Extractable K_2O ppm	.35**	0.019	172
Extractable Ca ppm	-.29**	<0.001	172
Extractable Mg ppm	-.33**	<0.001	172
Available S ppm	-.19*	.012	172

** indicate significant at 1%,* indicate significant at 5% and n means number of studied samples

Relationship between soil organic matter and total nitrogen

The result relating correlation revealed that the total nitrogen **(**r=.73**) were significantly and positively correlated with organic matter (Table 3). This suggested that organic matter accounted for about 52.8% of the total variability on total nitrogen (Figure 2).Similarly, by the increase on organic matter, total nitrogen increases progressively and vice-versa. In addition to this, with the increase on organic matter by one unit, total nitrogen increases by 0.038 unit and vice-versa.

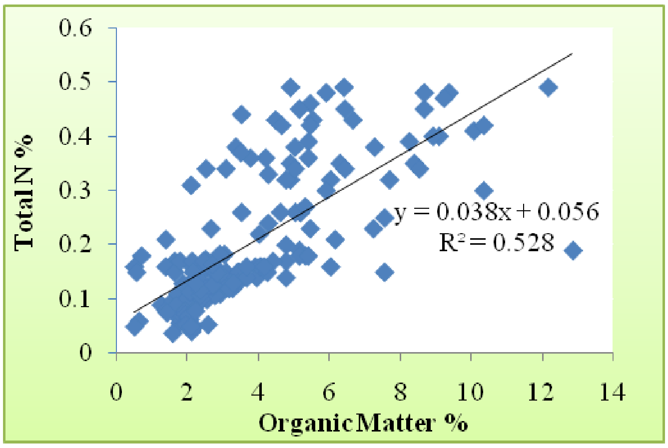

Figure 2. Regression relationship between organic matter and total nitrogen on the studied samples

Soil organic matter holds 90 to 95 % of the nitrogen held in soils. Soil organic matter is the main source of total nitrogen. Therefore, the relation is directly proportional between soil organic matter and total nitrogen. The obtained result was accordance with the result obtained by Singh and Mishra (2012), Athokpam *et al.* (2013), Habtamu *et al.* (2014) and Kumar *et al.* (2014).

Relationship between soil organic matter and available phosphorus

The result regarding correlation showed that the available phosphorus **(r=**.57**) were significantly and positively correlated with organic matter (Table 3). This suggested that organic matter accounted for about 32.6% of the total variability on available phosphorus (Figure 3). Similarly, by the increase on organic matter, available phosphorus increases progressively and vice-versa. In addition to this, with the increase on organic matter by one unit, available phosphorus increases by 31.19 unit and vice-versa.

A large proportion of the P can be tied up with organic matter, up to 80% (Stevenson 1982), and called organic phosphorus. When organic phosphorus mineralized available phosphorus ($H_2PO_4^-$/ $H_2PO_4^{-2}$) content increased in the soil. Therefore, the directly proportional relation was observed between soil organic matter and available phosphorus. The correspondence result was also found by Kabala *et al.* (2009), Athokpam *et al.* (2013), Kumar *et al.* (2014) and Patel *et al.* (2014). While, the positive non-significant correlation was obtained by Habtamu *et al.* (2014).

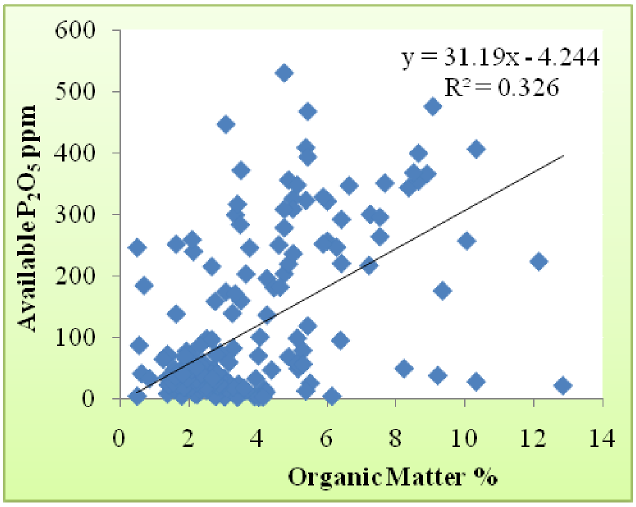

Figure 3. Regression relationship between organic matter and available phosphorus on the studied samples

Relationship between soil organic matter and extractable potassium

The result involving correlation revealed that the extractable potassium (r=.35**) were significantly and positively correlated with organic matter (Table 3). This suggested that organic matter accounted for about 11.9% of the total variability on extractable potassium (Figure 4). Similarly by the increase on organic matter, extractable potassium increases progressively and vice-versa. In addition to this, with the increase on soil organic matter by one unit, extractable potassium increases by 5.92 unit and vice-versa.

The organic matter plays important role to improve CEC of soils. The major contribution of K^+ on CEC might be the cause of directly proportional relation between soil organic matter and extractable potassium. The similar result was also obtained by Singh and Mishra (2012), Kabala *et al.* (2009), Athokpam *et al.* (2013) and Patel *et al.* (2014). The non-significant negative relation was obtained by Kumar *et al.* (2014).

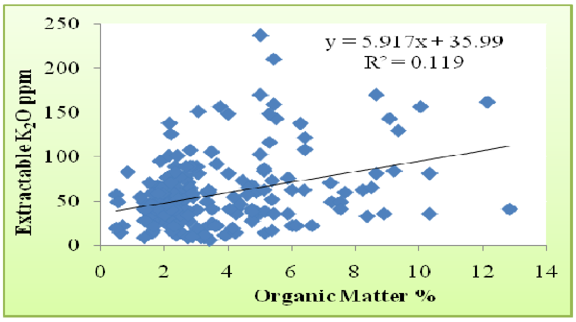

Figure 4. Regression relationship between organic matter and extractable potassium on the studied samples

Relationship between soil organic matter and extractable calcium

The result of the study presented in Table 3 indicated that extractable calcium (r=-.29**) were significantly and negatively correlated with organic matter. This suggested that organic matter accounted for about 8.6% of the total variability on extractable calcium (Figure 5). Correspondingly increasing organic matter, decreases extractable calcium gradually and vice-versa. In addition to this, with the increase on organic matter by one unit, extractable calcium decreases by 87.75 unit and vice-versa.

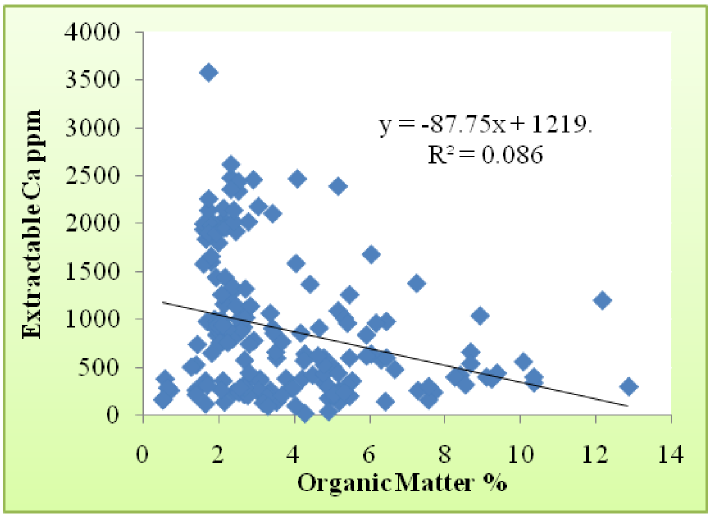

Figure 5. Regression relationship between organic matter and extractable calcium on the studied samples

The calcium is high available at alkaline soil reaction. Low organic matter at high pH and vice-versa (r=-.60**) might be the cause of inversely proportional relation between soil organic matter and extractable calcium. The contrast non-significant positive correlation was obtained by Medhe *et al.* (2012) and Habtamu *et al.* (2014).

Relationship between soil organic matter and extractable magnesium

Data presented in Table 3 showed that extractable magnesium (r=-.33**) were significantly and negatively correlated with organic matter. This suggested that organic matter accounted for about 10.6% of the total variability on extractable magnesium (Figure 6). Similarly increasing organic matter, extractable magnesium decreases gradually and vice-versa. In addition to this, with the increase on organic matter by one unit, extractable magnesium decreases by 13.39 unit and vice-versa.

Similar to calcium, magnesium is high available at alkaline soil reaction. Low organic matter at high pH and vice-versa (r=-.60**) might be the cause of inversely proportional relation between soil organic matter and extractable magnesium. The contrast significant but positive correlation was obtained by Kabala *et al.* (2009). While, the negative but non-significant correlation was obtained by Medhe *et al.* (2012). Whereas, non-significant positive relation was determined by Habtamu *et al.* (2014).

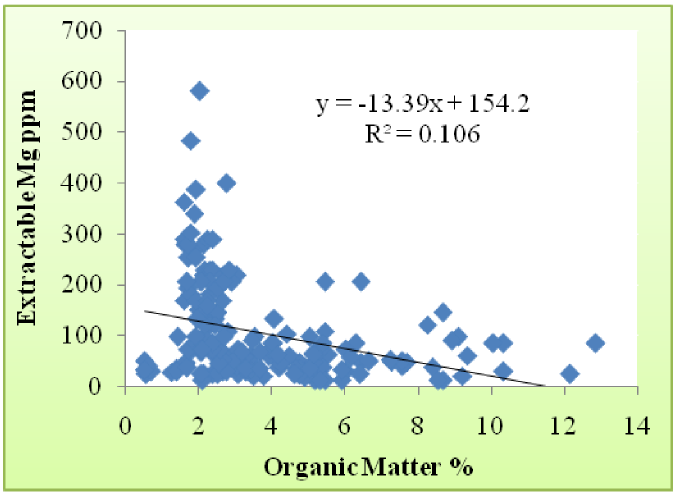

Figure 6. Regression relationship between organic matter and extractable magnesium on the studied samples

Relationship between soil organic matter and available sulphur

The result concerning correlation revealed that the available sulphur (r=-.19**) were significantly and negatively correlated with organic matter (Table 3). This suggested that organic matter accounted for about 3.6% of the total variability on available sulphur (Figure 7). Similarly by the increase on organic matter, available sulphur decreases gradually and vice-versa. In addition to this, with the increase on organic matter by one unit, available sulphur decreases by 0.37 unit and vice-versa.

About 90 to 95% of the S is in the soil organic matter. The inversely proportional relation was observed between soil organic matter and available sulphur. The movement of the nutrients between the soil organic matter store and the soil solution where it is available to plants is the function of soil microorganisms. Therefore, high organic sulphur mineralizing microorganism population (e.g. *Thiobacillus sp.*) on the low organic matter site might be the cause of high sulphur availability. The contrast significant but positive correlation was obtained by Singh and Mishra (2012), Acquaye and Beringer (1989) and Habtamu *et al.* (2014). The negative but non-significant correlation was obtained by Medhe *et al.* (2012) and Patel *et al.* (2014).

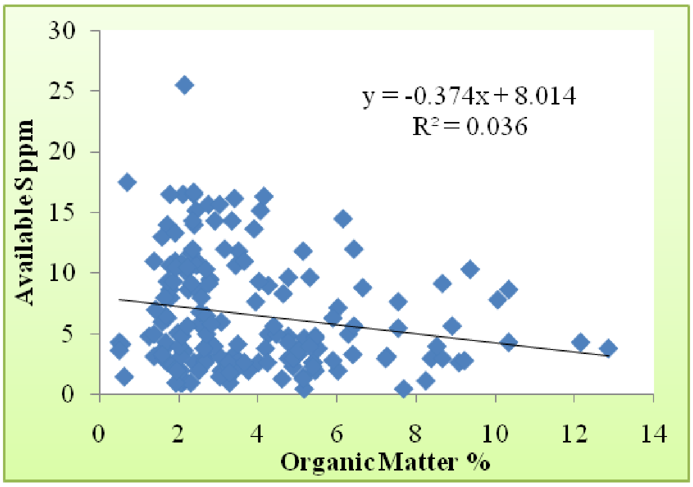

Figure 7. Regression relationship between organic matter and available sulphur on the studied samples

CONCLUSION

Soil organic matter is central to nutrient cycling and nutrient supply in most soils. The significant and positive correlation was observed between organic matter and primary nutrients (total nitrogen, available phosphorus and extractable potassium). Whereas, significant and negative correlation was obtained with secondary nutrients namely; extractable calcium, magnesium and available sulphur. With the increase on organic matter, primary nutrients increases gradually and vice-versa. On the other hand, secondary nutrients decreases consequently and vice-versa. Thus, the soil organic matter controls the availability of macronutrients. The studied data showed high availability of primary nutrients at high soil organic matter, while secondary nutrients were high available at low soil organic matter. Therefore, the maintenance of optimal soil organic matter is imperative to make macronutrients concentration balanced in western Nepal.

ACKNOWLEDGEMENT

The author gratefully acknowledges the Nepal Agricultural Research Council for funding the study. Deep appreciation is expressed to Regional Agricultural Research Station, Lumle; Horticulture Research Station, Malepatan and National Wheat Research Program, Bhairahawa for providing assistance for the collection of soil samples. Similarly, support of the Soil Science Division, Khumaltar, Lalitpur for providing laboratory facilities to analyze the soil samples and other necessary facilities to carry out this study is highly acclaimed.

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