Journal of Maize Research and Development (2017) 3 (1):28-44
ISSN: 2467-9291 (Print), 2467-9305 (Online)
DOI: http://dx.doi.org/10.3126/jmrd.v3i1.18918

Soil physico-chemical characterization in the different soil layers of National Maize Research Program, Rampur, Chitwan, Nepal

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Received: May 23, 2017; Revised: August 17, 2017; Accepted: October 19, 2017

ABSTRACT

Soil pit digging and their precise study is a decision making tool to assess history and future of soil management of a particular area. Thus, the present study was carried out to differentiate soil physico-chemical properties in the different layers of excavated pit of the National Maize Research Program, Rampur, Chitwan, Nepal. Eight pits were dug randomly from three blocks at a depth of 0 to 100 cm. The soil parameters were determined in-situ, and in laboratory for texture, pH, OM, N, P (as P_2O_5), K (as K_2O), Ca, Mg, S, B, Fe, Zn, Cu and Mn of collected soils samples of different layers following standard analytical methods at Soil Science Division, Khumaltar. The result revealed that soil structure was sub-angular in majority of the layers, whereas bottom layer was single grained. The value and chrome of colour was increasing in order from surface to bottom in the majority pits. Similarly, the texture was sandy loam in majority layers of the pits. Moreover, four types of consistence (loose to firm) were observed. Furthermore, mottles and gravels were absent in the majority layers. Likewise, soil was very to moderately acidic in observed layers of majority pits, except bottom layer of agronomy block was slightly acidic. Regarding fertility parameters (OM, macro and micronutrients), some were increasing and vice-versa, while others were intermittent also. Therefore, a single layer is not dominant for particular soil physico-chemical parameters in the farm. In overall, surface layer is more fertile than rest of the layers in all the pits.

Keywords: Chemical properties; Maize research; Physical properties; Pit study; Soil layers

Correct citation: Khadka, D., Lamichhane, S., Timilsina, A. P., Baral, B. R., Sah, K., Joshi, B. D., Joshi, S., & Adhikari, P. (2017). Soil physico-chemical characterization in the different soil layers of National Maize Research Program, Rampur, Chitwan, Nepal. *Journal of Maize Research and Development*, *3* (1), 28-44. doi: http://dx.doi.org/10.3126/jmrd.v3i1.18918

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INTRODUCTION

Soil is a unique natural resource for sustaining life of human being and agricultural development in the earth (Das et al., 2009). The soil develops from the rocks, through weathering process. The rocks are possessed at lower depth of the soil layer. If we dug the soil below the surface, and started to study separately about the observed layers have a peculiar meaning for their development as well adopted soil management practices. Therefore, pit digging and there details study plays important role for enhancing knowledge about the specific soil system as well helps to make sustainable land use planning. In other word, the differentiation of different layers in the excavated pit, and their systematic study provides history and future of an area for economic production through sustainable soil management (Brady & Weil, 2004).

The different layers have different physico-chemical properties. A single layer may not be superior for all the parameters. The different observations of layers like depth, distinctness of boundary and their topography, structure, consistence, colour, abundance of mottles, gravels, roots etc. can be determined in-situ condition. The colour is composed of hue, value and chrome (Goswami et al., 2009). Hue is considered as the dominant spectral colour such as red, yellow, green, blue and violet, whereas value is the lightness or darkness of colour ranging from 1(dark) to 8 (light), and chrome is the purity or strength of colour varying from 1 (pale) to 8 (bright) (Mikkelsen et al., 2009). Moreover, soil consistence referred to the resistance of soil materials to deformation or compression (Panda, 2010). Similarly, texture, Soil reaction (pH), organic matter, macro and micronutrients content in the different soil layers can be determined in the laboratory. These parameters symbolize how the human beings are using the soils, and how natural processes are running inside the soil which we cannot observe directly in the surface.

Nepal Agricultural Research Council (NARC) was established to strengthen agriculture sector in the country through agriculture research. In terms of area and production, maize (*Zea mays* L.) is a second most important crop after rice (*Oryza sativa* L.) in Nepal (KC, 2015).National Maize Research Program, Rampur, Chitwan, Nepal is an important wing among the research farms of NARC, in order to generate appropriate maize production technologies for the Nepal. Studies (in-situ and laboratory) related to different soil layers through pit digging in the different blocks of National Maize Research Program, Rampur, Chitwan, Nepal are not done yet. Previously, studies are only focused towards surface layer's soil fertility assessment and mapping only. Keeping these facts, the present study was conducted with the objective to determine soil physico-chemical properties in the different soil layer of crop growing blocks (seed production, agronomy and research) of National Maize Research Program, Rampur, Chitwan, Nepal. This may provide valuable information relating maize and other crop's research improvement through sustainable planning in the particular block.

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MATERIALS AND METHODS

Study Area Descriptions

The study was carried out at National Maize Research Program, Rampur, Nepal (Figure 1). The research farm is situated at the latitude 27°40'36" and longitude 84°21'24" as well altitude 173masl. The studied area lies in inner terai region, and near to longest river (Naryani) of Nepal. Moreover, humid and sub-tropical with cool winter (2 to 3^{o}C) and hot summer (43^{o}C) climatic condition. The annual rainfall is >1500 mm, where monsoon period (>75% of annual rainfall) starts from mid-June to mid-September (Nepal Agricultural Research Council [NARC], 2007).

Field Study and Soil Sampling

The total eight pits were dug at depth 0 to 100 cm in different sites of National Maize Research Program, Rampur, Nepal during March 2015 (Figure 1). Four pits were dug in Seed production block; two pits were in Agronomy block and rest two pits were in Research block. The positioning of the pits was recorded using a handheld GPS receiver (Table 1). Soil physico-chemical characterizations were done in-situ as well in the laboratory. During in-situ study each layer were observed for depth, boundary (distinctness), boundary (topography), soil colour, structure (type), consistence (dry/moist/wet), mottles (abundance), Roots (abundance) and gravels (abundance). The soil colour was determined by Munshell-colour chart. Soil samples were collected from each layer for the laboratory analysis of different physico-chemical properties.

Laboratory Analysis

The collected soil samples were analyzed at Soil Science Division, Khumaltar laboratory. The different soil parameters tested as well as methods adopted to analyze is shown on the Table 2.

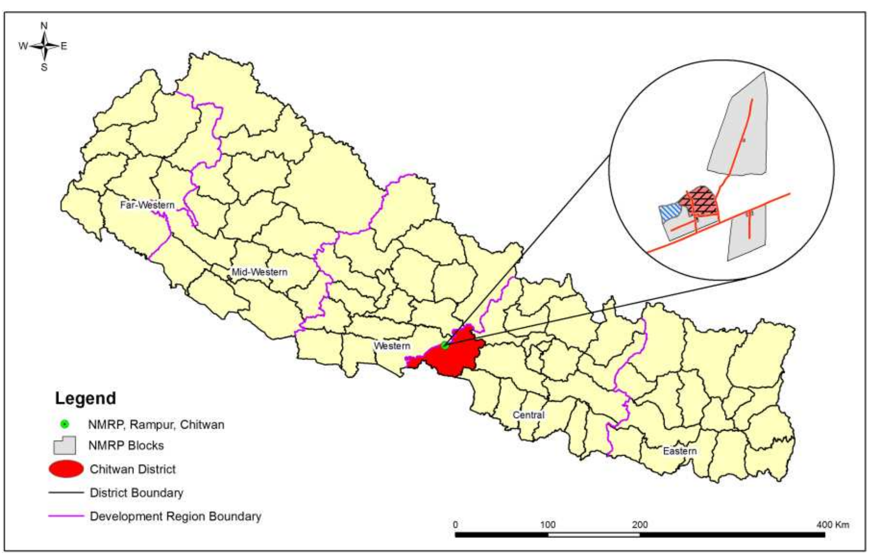

Figure 1. Location Map of National Maize Research Program, Rampur, Chitwan, Nepal

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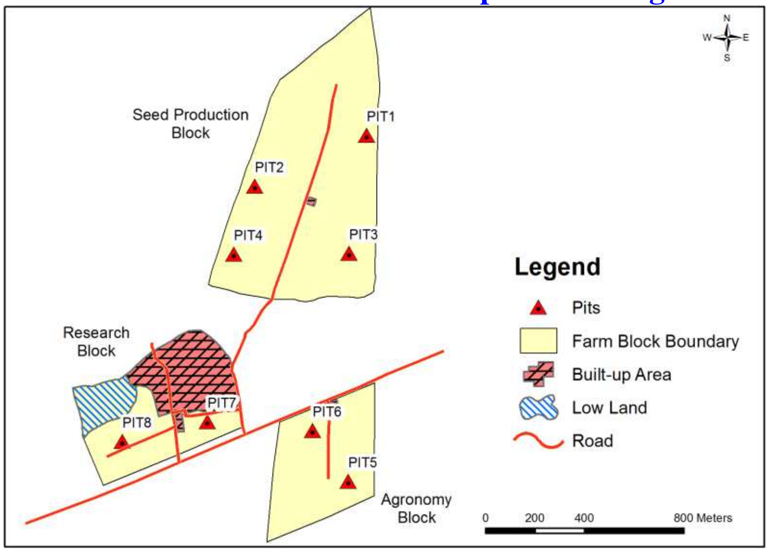

Figure 2. Distribution of Pit Sampling Points in the Different Blocks of National Maize Research Program, Rampur, Chitwan, Nepal

Table 1. Global Positioning of the Pits dug in National Maize Research Program, Rampur, Chitwan, Nepal

SN	Pit No	Latitude	Longitude	Elevation
1	1	27°40’53”	84°21’28”	177.54masl
2	2	27°40’46”	84°21’40”	176.76masl
3	3	27°40’38”	84°21’26”	177.08masl
4	4	27°40’37”	84°21’40”	170.92masl
5	5	27°39’08”	84°21’27”	187.78masl
6	6	27°39’14”	84°21’21”	171.28masl
7	7	27°39’15”	84°21’06”	173.29masl
8	8	27°39’12”	84°21’53”	179.40masl

Table 2. Parameters and Methods Adopted for the Laboratory Analysis at Soil Science Division, Khumaltar

S.N.	Parameters	Unit	Methods
1.	**Physical**		
	Soil texture		Hydrometer (Bouyoucos, 1927)
	Soil structure		Field-feel
2.	**Chemical**		
	Soil pH		Potentiometric 1:2 (Jackson, 1973)
	Organic matter	%	Walkely and Black (Walkely and Black, 1934)
	Total N	%	Kjeldahl (Bremner and Mulvaney, 1982)
	Available P (as P_2O_5)	mg/kg	Olsen’s (Olsen et al., 1954)
	Available K (as K_2O)	mg/kg	Ammonium acetate (Jackson, 1967)
	Available Ca	mg/kg	EDTA Titration (El Mahi et al.,1987)
	Available Mg	mg/kg	EDTA Titration (El Mahi et.al.,1987)
	Available S	mg/kg	Turbidimetric (Verma, 1977)
	Available B	mg/kg	Hot water (Berger and Truog, 1939)
	Available Fe	mg/kg	DTPA (Lindsay and Norvell, 1978)
	Available Zn	mg/kg	DTPA (Lindsay and Norvell, 1978)
	Available Cu	mg/kg	DTPA (Lindsay and Norvell, 1978)
	Available Mn	mg/kg	DTPA (Lindsay and Norvell, 1978)

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RESULTS AND DISCUSSION

Soil Physico-chemical Characterization in the Different Soil Layer of Seed Production Block

The field observed and laboratory data pertaining different soil layers (0 to 100cm) of seed production block is shown in the Table 3 to 6.

In-situ Observations

There were two soil layers in three pits, while three layers contains in one pit (pit 3). The depth of soil layers in all the pits was different. The distinctness of the boundary indicates thickness between two adjacent layer (FAO, 2006).The distinctness of the boundaries between the layer was abrupt (<2 cm) in all the pits. Similarly, topography refers shape of the boundary (FAO, 2006). Two types of topography smooth (2 pits) and wavy (2 pits) were determined. The colour was different in the different soil layers of the pits. Hue (10YR) was similar in observed layers of all the pits, value was constant in all the pits except pit 1, and chrome was increasing from surface to bottom layers of all the pits.

The consistence depends upon the nature and availability of clay, organic matter and moisture content of the soil. The consistence in the majority of layers was friable. This indicates this block is suitable for agricultural purposes. Mottles are spots of various colours dispersed with the dominant colour of the soil (FAO, 2006). Mottles were absent in observed layers of all the pits. This argues good drainage status, and ground water table is far below the studied depth. Similarly, amounts of roots were denser in surface layer than lower layer in all the pits. Likewise, gravels were also absent in all the layers of the pits. Absence of gravels in the layers signifies, there are no obstacles for root growth, and uptake of water and nutrients from soil.

Laboratory Observations

The acidic pH was observed in the observed layer of all the pits. Similarly, upper layer is more acidic than other layers except in pit 1. Upper layer is more acidic than others might be due to more influence of crop production activity in this layer. Consistent result was also obtained during surface (0 to 20cm) soil fertility assessment and mapping of the seed production block of National Maize Research Program, Rampur, Chitwan, Nepal (Khadka et al., 2016). The different agricultural activities running during crop production enhances soil acidity in long-term (Havlin et al., 2010).The organic matter, total nitrogen, available phosphorus (as P_2O_5), available potassium (as K_2O), available sulphur, available boron, available iron, available zinc, available copper and available manganese content was decreasing in order from top to bottom layers in majority of the pits. Whereas, the pattern of available calcium and magnesium was intermittent. The textural class was sandy loam in all the layers of pits. The satisfactory condition in soil fertility at upper layer of all the pits indicates current soil fertility management practice is sustainable for the crop growth and development in the seed production block.

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Table 3. Soil Physico-Chemical Characterization in the Different Soil Layers of Seed Production Block (Pit 1)

Description	Layer	
	First	Second
Depth (cm)	0 to 74	74 to 100
Boundary (distinctness)	abrupt	
Boundary (topography)	smooth	
Colour	10YR 4/3, dark brown	10YR 5/6, yellowish brown
Structure (types)	sub-angular blocky	single grained
Consistence (moist)	friable	very friable
Mottles	absent	absent
Roots (abundance)	few	very few
Gravels	absent	absent
pH	5.9	5.35
OM (%)	3.3	1.5
N (%)	0.13	0.08
P_2O_5 (mg/kg)	9.81	118.14
K_2O (mg/kg)	69.60	9.60
Ca (mg/kg)	120	200
Mg (mg/kg)	112.8	76.8
S (mg/kg)	0.2	0.1
B (mg/kg)	0.54	0.51
Fe (mg/kg)	7.82	3.32
Zn (mg/kg)	0.08	0.06
Cu (mg/kg)	0.34	0.24
Mn (mg/kg)	2.18	1.86
Sand (%)	63	71
Silt (%)	28.2	22.2
Clay (%)	8.8	6.8
Texture Class	sandy loam	sandy loam

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Table 4. Soil Physico-Chemical Characterization in the Different Soil Layers of Seed Production Block (Pit 2)

Description	Layer	
	First	Second
Depth (cm)	0 to 30	30 to 100
Boundary (distinctness)	abrupt	
Boundary (topography)	smooth	
Colour	10YR 3/2, very dark grayish brown	10YR 3/3, dark brown
Structure (types)	sub-angular blocky	sub-angular blocky
Consistence (moist)	friable	friable
Mottles	absent	absent
Roots (abundance)	few	few
Gravels	absent	absent
pH	5.29	5.57
OM (%)	2.9	3.6
N (%)	0.12	0.14
P_2O_5 (mg/kg)	76.73	8.07
K_2O (mg/kg)	69.60	69.60
Ca (mg/kg)	420	220
Mg (mg/kg)	124.8	136.8
S (mg/kg)	0.7	0.3
B (mg/kg)	0.50	0.51
Fe (mg/kg)	9.76	6.16
Zn (mg/kg)	0.5	0.4
Cu (mg/kg)	0.42	0.38
Mn (mg/kg)	2.14	2.36
Sand (%)	69	71
Silt (%)	22.2	20.2
Clay (%)	8.8	8.8
Texture Class	sandy loam	sandy loam

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Table 5. Soil Physico-Chemical Characterization in the Different Soil Layers of Seed Production Block (Pit 3)

Description	Layer		
	First	Second	Third
Depth (cm)	0 to 25	25 to 65	65 to 100
Boundary (distinctness)	abrupt	abrupt	
Boundary (topography)	wavy	wavy	
Colour	10YR 4/3, dark grayish brown	10YR 4/4, brown	10YR 4/4, dark yellowish brown
Structure (types)	sub-angular blocky	sub-angular blocky	single grain (dominant); sub-angular blocky (also present)
Consistence (moist)	firm	friable	friable
Mottles	absent	absent	absent
Roots (abundance)	few	few	very few
Gravels	absent	absent	absent
pH	4.77	5.21	5.17
OM (%)	4.5	2.8	1.8
N (%)	0.17	0.12	0.09
P_2O_5 (mg/kg)	102.45	19.18	18.96
K_2O (mg/kg)	153.62	81.61	57.59
Ca (mg/kg)	360	140	200
Mg (mg/kg)	172.8	148.8	100.8
S (mg/kg)	1.1	0.3	0.1
B (mg/kg)	0.75	0.67	0.33
Fe (mg/kg)	14.8	4.76	3.52
Zn (mg/kg)	0.42	0.3	0.27
Cu (mg/kg)	0.58	0.32	0.22
Mn (mg/kg)	5.92	2.06	1.62
Sand (%)	71	57	61
Silt (%)	20.2	34.2	32.2
Clay (%)	8.8	8.8	6.8
Texture Class	sandy loam	sandy loam	sandy loam

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Table 6. Soil Physico-Chemical Characterization in the Different Soil Layers of Seed Production Block (Pit 4)

Description	Layer	
	First	Second
Depth (cm)	0 to 20	20 to 100
Boundary (distinctness)	abrupt	
Boundary (topography)	wavy	
Colour	10YR 4/2, dark grayish brown	10YR 4/3, brown
Structure (types)	sub-angular blocky	sub-angular blocky (dominant), single grain (also present)
Consistence (moist)	firm	very friable
Mottles	absent	absent
Roots (abundance)	few	few
Gravels	absent	absent
pH	4.67	5.0
OM (%)	4.6	2.7
N (%)	0.17	0.12
P_2O_5 (mg/kg)	129.92	12.86
K_2O (mg/kg)	141.61	63.62
Ca (mg/kg)	340	80
Mg (mg/kg)	76.8	100.8
S (mg/kg)	0.7	0.2
B (mg/kg)	0.92	0.32
Fe (mg/kg)	15.94	5.72
Zn (mg/kg)	0.48	0.45
Cu (mg/kg)	0.5	0.38
Mn (mg/kg)	2.78	2.42
Sand (%)	73	61
Silt (%)	20.2	30.2
Clay (%)	6.8	8.8
Texture Class	sandy loam	sandy loam

ISSN: 2467-9291 (Print), 2467-9305 (Online)
DOI: http://dx.doi.org/10.3126/jmrd.v3i1.18918

Soil Physico-Chemical Characterization in the Different Soil Layer of Agronomy Block

The field observed and laboratory data showing different soil layers (0 to 100cm) of Agronomy block is shown in the Table 7 and 8.

In-situ Observations

The number of soil layer and their depth was different in all the pits (Table 7; Table 8). The distinctness of the boundaries between the layers was clear (2 to 5 cm) and gradual (5 to 15 cm). Similarly, topography of boundary was smooth and wavy. Similar to seed production block, hue (10YR) was similar in observed layers of all the pits, while value was more in bottom layer than surface layer, and chrome was more or less similar in pit 5 but in pit 6 increasing towards bottom layers.

Regarding consistence, similar to seed production block, majority of the layers were friable, where bottom layers were more friable than surface layer. This also indicates this block is also suitable for the agricultural purpose. Mottles were present in all the layers of pits, except two above layer of pit 5. The abundance of mottles was few (2 to 5%) and common (5 to 15%). This indicates slightly poor drainage status, and ground water table is nearer to the studied depth. Furthermore, abundance of roots was more in surface layer than bottom layer in all the pits. Likewise, gravels were absent in majority of the layers of pits, but few amount was observed in bottom layer of pit 5.

Laboratory Observations

Similar to seed production block soil pH was acidic in observed layer of all the pits. Corresponding result was also obtained during soil fertility assessment and mapping of agronomy block of National Maize Research Program, Rampur, Chitwan, Nepal at 0 to 20 cm depth (Khadka et al., 2016). The bottom layer of both pits was slightly acidic, while other layers were moderately acidic in nature. Upper layer is more acidic than others might be due to more influence of crop production activity in above layers. The organic matter, total nitrogen, available phosphorus (as P_2O_5), available potassium (as K_2O), available sulphur, available boron, available iron, available zinc and available copper content was decreasing in order from top to bottom majority layers in both pits. Whereas, the pattern of available calcium and magnesium was intermittent in order form top to bottom layers, but higher content in surface layer of both pits. Correspondingly, the pattern of available manganese was intermittent in all the layers from top to bottom but higher in bottom layer than others in both pits. Regarding soil texture, the proportion of sand was increasing in order from top to bottom layers, while silt and clay proportion decreasing in order. Four types textural class (sandy loam, loam, loamy sand and sand) was observed in the different layers of both pits.

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Table 7. Soil Physico-Chemical Characterization in the Different Soil Layers of Agronomy Block (Pit 5)

Description	Layers			
	First	Second	Third	Fourth
Depth (cm)	0 to 20	20 to 40	40 to 70	70 to 100
Boundary (distinctness)	gradual	gradual	clear	
Boundary (topography)	wavy	smooth	smooth	
Colour	10YR 3/2, very dark grayish brown	10YR 3/3, dark brown	10YR 6/2, light brownish gray	10 YR 6/2, light brownish gray
Structure (types)	angular blocky	sub-angular blocky	sub-angular blocky	single grained
Consistence (moist)	firm	friable	friable	loose
Mottles	absent	absent	few	common
Roots (abundance)	few	few	very few	absent
Gravels	absent	absent	absent	few
pH	5.61	5.78	5.94	6.27
OM (%)	4.6	3	0.9	0.6
N (%)	0.17	0.13	0.06	0.06
P_2O_5 (mg/kg)	8.50	0.58	0.54	0.65
K_2O (mg/kg)	51.61	39.60	39.60	27.59
Ca (mg/kg)	420	220	160	200
Mg (mg/kg)	328.8	52.8	88.8	52.8
S (mg/kg)	2.1	0.9	0.6	0.6
B (mg/kg)	0.46	0.40	0.43	0.08
Fe (mg/kg)	65.9	12.46	5.6	7.2
Zn (mg/kg)	0.48	0.08	0.086	0.046
Cu (mg/kg)	2.7	0.64	0.22	0.1
Mn (mg/kg)	5.3	0.34	0.5	6.2
Sand (%)	51	61	47	89
Silt (%)	38.2	30.2	44.2	4.2
Clay (%)	10.8	8.8	8.8	6.8
Texture Class	loam	sandy loam	loam	sand

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Table 8. Soil Physico-Chemical Characterization in the Different Soil Layers of Agronomy Block (Pit 6)

Description	Layers		
	First	Second	Third
Depth (cm)	0 to 20	20 to 60	60 to 100
Boundary (distinctness)	clear	clear	
Boundary (topography)	wavy	wavy	
Colour	10YR 5/2, grayish brown	10YR 5/3, brown	10YR 6/6, brownish yellow
Structure (types)	sub-angular blocky	sub-angular blocky	single grained
Consistence (moist)	firm	friable	loose
Mottles	few	few	common
Roots (abundance)	few	few	very few
Gravels	absent	absent	few
pH	5.83	5.78	6.24
OM (%)	2.3	1.6	0.5
N (%)	0.11	0.09	0.05
P_2O_5 (mg/kg)	66.27	4.58	1.31
K_2O (mg/kg)	99.60	51.61	27.59
Ca (mg/kg)	440	380	140
Mg (mg/kg)	172.8	52.8	100.8
S (mg/kg)	0.4	0.4	0.3
B (mg/kg)	1.35	0.60	0.23
Fe (mg/kg)	55.56	12.54	6.02
Zn (mg/kg)	0.4	0.14	0.06
Cu (mg/kg)	1.34	0.62	0.22
Mn (mg/kg)	3.14	3.26	6.52
Sand (%)	63.3	65.3	79.3
Silt (%)	27.9	25.9	13.9
Clay (%)	8.8	8.8	6.8
Texture Class	sandy loam	sandy loam	loamy sand

ISSN: 2467-9291 (Print), 2467-9305 (Online)
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Soil Physico-Chemical Characterization in the Different Soil Layers of Research Block

The field observed and laboratory data regarding different soil layers (0 to 100cm) of Research block is shown in the Table 9 to 10.

In-situ Observations

The number of soil layer was same but depth was different in both pits. The distinctness of the boundaries between the layer was clear (2 to 5 cm) in all the pits. Similarly, topography of the boundaries was smooth and wavy. Hue (10YR) was similar, while value and chrome was increasing in order from surface to bottom layers. The trend was consistent in chrome. Regarding consistence, two types of consistence namely firm and friable were determined, where bottom layer were more friable than surface layer. Mottles were absent in majority of the layers, except few in second and third layer of pit 7. This indicates good drainage status, and ground water table is below the studied depth. Furthermore, similar to above blocks amounts of roots were denser in surface layer than lower layer in both pits. Likewise, gravels were absent in the majority of the layers, except very few in second layers of pit 8.

Laboratory Observations

Soil pH was very acidic to moderately acidic in all the layer of both pits. Consistent result was also obtained during soil fertility assessment and mapping of research block of National Maize Research Program, Rampur, Chitwan, Nepal at 0 to 20 cm depth (Khadka et al., 2016).The organic matter, total nitrogen, available phosphorus (as P_2O_5), available potassium (as K_2O), available magnesium, available iron, available zinc, available copper and available manganese were decreasing in order from surface to bottom layers. Whereas, the pattern of available calcium, available sulphur and available boron intermittent. Regarding texture, sand content was increasing in order from top to bottom layers of pits, while silt content was decreasing in order. Furthermore, clay content was similar in one pit, while inconsistently decreasing in another pit. The textural class was sandy loam in majority of the layers, except loamy sand in third layer of pit 8.

Journal of Maize Research and Development (2017) 3 (1):28-44
ISSN: 2467-9291 (Print), 2467-9305 (Online)
DOI: http://dx.doi.org/10.3126/jmrd.v3i1.18918

Table 9. Soil Physico-Chemical Characterization in the Different Soil Layers of Research Block (Pit 7)

Description	Layers		
	First	Second	Third
Depth (cm)	0 to 44	44 to 72	72 to 100
Boundary (distinctness)	clear	clear	
Boundary (topography)	smooth	wavy	
Colour	10YR 4/3, brown	10YR 5/4, yellowish brown	10YR 5/6, yellowish brown
Structure (types)	sub-angular blocky	sub-angular blocky	single grain (dominant); sub-angular blocky (also present)
Consistence (moist)	firm	firm	friable
Mottles	absent	few	few
Roots (abundance)	few	few	very few
Gravels	absent	absent	absent
pH	5.53	5.2	5.31
OM (%)	2.4	2.5	0.7
N (%)	0.11	0.11	0.06
P_2O_5 (mg/kg)	74.77	8.50	5.45
K_2O (mg/kg)	75.58	33.62	27.59
Ca (mg/kg)	460	120	140
Mg (mg/kg)	88.8	64.8	52.8
S (mg/kg)	0.5	0.2	0.6
B (mg/kg)	0.79	0.42	0.61
Fe (mg/kg)	21.78	8.06	4.14
Zn (mg/kg)	0.6	0.08	0.02
Cu (mg/kg)	1.78	0.19	0.08
Mn (mg/kg)	8.56	0.82	1.64
Sand (%)	65.3	69.3	71.3
Silt (%)	25.9	21.9	19.9
Clay (%)	8.8	8.8	8.8
Texture Class	sandy loam	sandy loam	sandy loam

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DOI: http://dx.doi.org/10.3126/jmrd.v3i1.18918

Table 10. Soil Physico-Chemical Characterization in the Different Soil Layers of Research Block (Pit 8)

Description	Layers		
	First	Second	Third
Depth (cm)	0 to 30	30 to 90	90 to 100
Boundary (distinctness)	clear	clear	
Boundary (topography)	smooth	smooth	
Colour	10YR 4/3, brown	10YR 4/4, dark yellowish brown	10YR 5/6, yellowish brown
Structure (types)	sub-angular blocky	sub-angular blocky	single grained
Consistence (moist)	firm	friable	loose
Mottles	absent	absent	absent
Roots (abundance)	few	few	very few
Gravels	absent	very few	absent
pH	5.14	5.41	5.55
OM (%)	2.3	1.7	1.3
N (%)	0.11	0.09	0.08
P_2O_5 (mg/kg)	219.29	11.55	13.95
K_2O (mg/kg)	87.59	51.61	27.59
Ca (mg/kg)	260	120	200
Mg (mg/kg)	112.8	64.8	64.8
S (mg/kg)	0.6	0.8	0.5
B (mg/kg)	0.30	0.82	0.79
Fe (mg/kg)	10.86	6.42	4.62
Zn (mg/kg)	0.88	0.04	0.004
Cu (mg/kg)	0.24	0.14	0.04
Mn (mg/kg)	2.02	0.96	0.6
Sand (%)	71.3	75.3	81.3
Silt (%)	19.9	17.9	11.9
Clay (%)	8.8	6.8	6.8
Texture Class	sandy loam	sandy loam	loamy sand

CONCLUSION

The numbers of layers in the pits were 2 to 4 in the different sites of the blocks. The depth of the layers was different in all the pits. The structure, consistence and texture were satisfactory for long-term farming. The tillage operation, crop root growth may be appropriate due to satisfactory structure, consistence and texture. Similarly, abundance of mottles was absent or negligible means drainage status is good and ground water table is far below the excavated depth. This is good symbol for maize growth and development because maize crop cannot tolerate water stagnation. Likewise, the abundance of gravel was also absent or negligible means root growth is satisfactory as well no obstacles for nutrient and water uptake from soil to plants. The soil was acidic in all the layers of pits. The pattern of organic matter, macro and micronutrient as well as sand, silt and clay content was decreasing, increasing and intermittent from surface to bottom layers. A single layer is not dominant for all the physico-chemical properties in all the pits. In overall, upper layer is more fertile than other layers in all the pits.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Nepal Agricultural Research Council, Soil Science Division, Khumaltar, Lalitpur, Nepal for funding this research. They were thankful to National Maize Research Program, Rampur, Chitwan for providing technical support during this study.

AUTHOR CONTRIBUTIONS

D.K. conceptualized and designed the experiment. D.K., S.L., B.R.B. and P.A. studied pit layers in-situ, and collected soil samples for laboratory analysis. D.K. and S.J. analyzed collected soil samples in the Soil Science Division laboratory. D.K. wrote the paper, and final approval of the paper was done by A.P.T., K.S. and B.D. J.

CONFLICTS OF INTEREST

The authors declare that there is no conflicts of interest

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ISSN: 2467-9291 (Print), 2467-9305 (Online)
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