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RESEARCH ARTICLE

ASSESSMENT OF SOIL FERTILITY STATUS OF OILSEED RESEARCH PROGRAM, NAWALPUR, SARLAHI, NEPAL

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Abstract

Soil fertility evaluation is most basic decision making tool for the sustainable soil nutrient management of a particular area. Thus, the present study was carried out to assess the soil fertility status of the Oilseed Research Program (ORP), Nawalpur, Sarlahi, Nepal. The study area is situated at the latitude 27^o 3'35.8''N and longitude $85^0$35'15.4"E as well 130masl altitude. A total of 38 soil samples were randomly collected based on the variability of land at a depth of 0-20 cm. A GPS device was used to identify the location of the soil sampling points. Soil samples were analyzed for texture, pH, OM, N, P_2O_5, K_2O, Ca, Mg, S, B, Fe, Zn, Cu and Mn status following standard analytic methods in the laboratory of Soil Science Division, Khumaltar. The Arc-GIS 10.1 was used to prepare the soil fertility status maps. Assessment of soil test data showed that the structure was angular to sub-angular blocky and varied between brown- yellowish brown and dark grayish brown in colour. The sand, silt and clay content were 40.79±1.53%, 42.44±1.01% and 16.77±0.64%, respectively and categorized as loam and sandy loam in texture. The soil was acidic in pH (5.03±0.04) and low in extractable calcium (697.89±30 ppm), available sulphur (2.15± 0.19 ppm) and available zinc (0.92±0.07 ppm). Whereas, organic matter (2.02±0.11%), total nitrogen (0.1±0.001 %), extractable magnesium (109.89± 13.21ppm) and available copper (0.92±0.38 ppm) were medium in status. While, available phosphorus (51.83±4.68 ppm), extractable potassium (128.97±8.42 ppm), available boron (1.24±0.09 ppm) and available manganese (13.53±1.02 ppm) status were high. Similarly, available iron (107.2±10.5 ppm) contains very high status. From this study, it can be concluded that for enhancing efficacy of the oilseed crops research, future research strategy should be built based on the soil fertility status of the research farm.

Introduction:-

The evaluation of soil fertility is perhaps the most basic decision making tool for balanced and efficient nutrient management. It consists of estimating the available nutrient status of a soil for crop production. There are various techniques for soil fertility evaluation, among them soil testing is the most widely used research tool for making balanced and profit maximizing fertilizer recommendations, particularly for field crops. Soil testing can be defined as an acceptably accurate and rapid soil chemical analysis for assessing available nutrient status for making fertilizer recommendation(Roy et al., 2006).

The texture, structure, colour etc. are important soil physical parameters. Similarly, soil reaction (pH), organic matter, macro and micronutrients etc. are also important soil chemical parameters. These properties play important role for the soil fertility and determined after soil testing (Brady and Nelson, 2004). Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Describing the spatial variability of soil fertility across a field has been difficult until new technologies such as Global Positioning Systems (GPS) and Geographic Information Systems (GIS) were introduced. GIS is a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data (Burrough and McDonnell, 1998).

Nepal Agricultural Research Council (NARC) was established to strengthen agriculture sector in the country through agriculture research. Oilseed Research Program, Nawalpur, Sarlahi, Nepal is an important wing among the research farms of NARC, in order to generate appropriate oilseed crop production technologies for the Nepal. Studies related to the soil fertility status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal are scant. Therefore, it is important to investigate the soil fertility status and may provide valuable information relating oilseed crop research. Keeping these facts, the present study was conducted with the objective to assess the soil fertility status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal.

Materials and Methods:-

Study area:-

The study was carried out at Oilseed Research Program, Nawalpur, Sarlahi, Nepal (Figure 1). The research farm is situated at a latitude $27^{o}\,{}^{0}3'35.8''$N and longitude $85^{0}35'15.4''$E as well altitude 130 m above sea level.

Soil sampling:-

Surface soil samples (0-20 cm depth) were collected from Oilseed Research Program, Nawalpur, Sarlahi, Nepal during 2015. A total of 38 soil samples were collected from the research farm (Figure 2). The exact locations of the samples were recorded using a handheld GPS receiver. The random method based on the variability of the land was used for the soil samples collection.

Laboratory analysis:-

The collected soil samples were analyzed at laboratory of Soil Science Division, Khumaltar. The different soil parameters tested as well as methods adopted to analyze is shown on the Table 1.

Table 1:- Parameters and methods adopted for the laboratory analysis at Soil Science Division, Khumaltar

S.N.	Parameters	Units	Methods
1	Soil texture		Hydrometer (Bouyoucos, 1927)
2.	Soil colour		Munshell-colour chart
3.	Soil structure		Field-feel
4.	Soil pH		Potentiometric 1:2 (Jackson, 1973)
5.	Soil organic matter	%	Walkely and Black (Walkely and Black, 1934)
6.	Total N	%	Kjeldahl (Bremner and Mulvaney, 1982)
7.	Available P_2O_5	ppm	Olsen (Olsen et al., 1954)
8.	Extractable K_2O	ppm	Ammonium acetate (Jackson, 1967)
9.	Extractable Ca	ppm	EDTA Titration (El Mahi, et.al.,1987)
10.	Extractable Mg	ppm	EDTA Titration (El Mahi, et.al.,1987)
11.	Available S	ppm	Turbidimetric (Verma, 1977)
12.	Available B	ppm	Hot water (Berger and Truog, 1939)
13.	Available Fe	ppm	DTPA (Lindsay and Norvell, 1978)
14.	Available Zn	ppm	DTPA (Lindsay and Norvell, 1978)
15.	Available Mn	ppm	DTPA (Lindsay and Norvell, 1978)
16.	Available Cu	ppm	DTPA (Lindsay and Norvell, 1978)

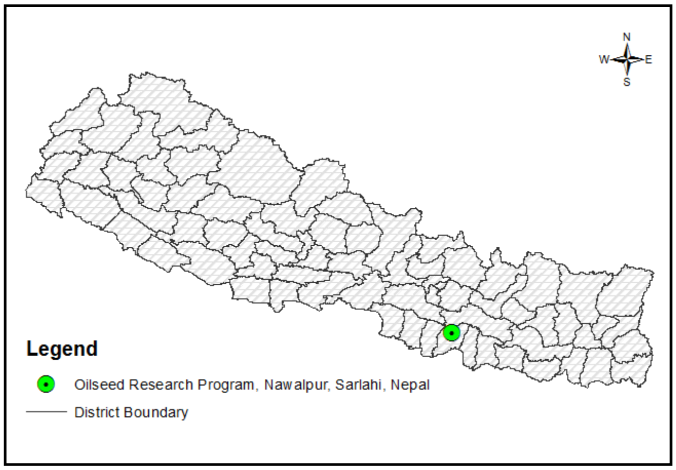

Figure 1:- Location Map of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

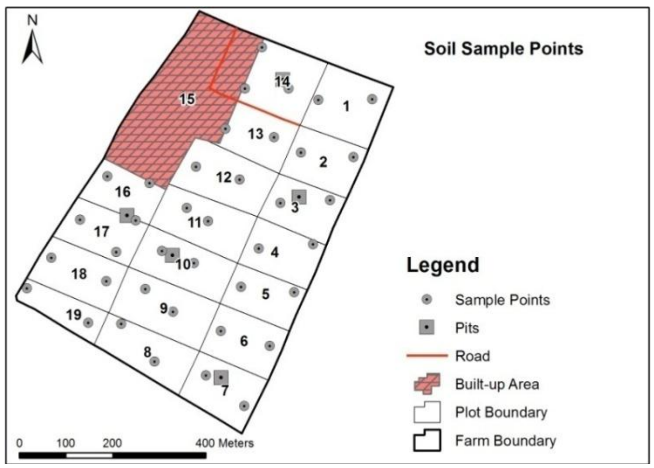

Figure 2:- Distribution of soil sample points during soil sampling

Statistical analysis:-

Descriptive statistics (mean, median, range, standard deviation, standard error, coefficient of variation) of soil parameters were computed using the Minitab 15 package. Rating (very low, low, medium, high and very high) of determined values were based on Soil Science Division, Khumaltar. The coefficient of variation was ranked according to the procedure of (Aweto, 1982) where, CV < 25% = low variation, CV >25 < 50% = moderate variation, CV >50% = high variation. Arc Map 10.1 with spatial analyst function of Arc GIS software was used to prepare soil fertility maps while interpolation method employed was ordinary kriging.

Similarly, the nutrient index was also determined by the formula given by Ramamoorthy and Bajaj (1969).

Nutrient Index (N.I.) = $(N_L \times 1 + N_M \times 2 + N_H \times 3) / N_T$

Where, N_L, N_M and N_H are number of samples falling in low, medium and high classes of nutrient status, respectively and N_T is total number of samples analyzed for a given area. Similarly, interpretation was done as value given by Ramamoorthy shown on the Table 2.

Table 2:- Rating chart of nutrient index

S.N.	Nutrient Index	Value
1.	Low	<1.67
2.	Medium	1.67-2.33
3.	High	>2.33

Result and Discussion:-

The soil fertility status of the study area was evaluated with respect to texture, colour, structure, pH, organic matter, primary nutrients, secondary nutrients and micronutrients such as B, Fe, Zn, Cu, and Mn and the results obtained are presented and discussed in the following paragraphs.

Soil texture:-

Soil texture determines a number of physical and chemical properties of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices (Gupta, 2004). The results in Figure 3 shows that soil texture of the study area were predominantly loam type. The % sand were ranged from 24.2 to 61.6 % with an average of 40.79 % and that of % silt were 26.2 to 54.2 % with an average of 42.44% while the range of % clay were 10.2 to 27.6 % with an average of 16.77% (Table 3). The coefficients of variation between the soil samples were 23.1%, 14.7% and 23.46% for sand, silt and clay contents, respectively.

Table 3:- Soil Separates Status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Descriptive Statistics	Soil Separates		
	Sand	Silt	Clay
	%		
Mean	40.79	42.44	16.77
Median	38.2	43.5	17
StDev	9.42	6.24	3.934
SE Mean	1.53	1.01	0.638
Minimum	24.2	26.2	10.2
Maximum	61.6	54.2	27.6
CV%	23.1	14.7	23.46

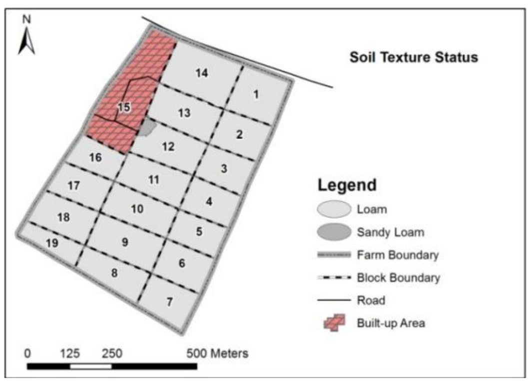

Figure 3:- Soil texture status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Soil colour:-

Soil colour is an important soil parameter because it is an indirect measure of other important characteristics such as water drainage, aeration, and organic matter content (Foth, 1990). The different soil colour observed on the study area were 10YR 5/3 (brown), 10YR 4/3 (brown), 10YR 5/4 (yellowish brown) and 10YR 4/2 (dark grayish brown).

Soil structure:-

Soil structure refers to the pattern of spatial arrangement of soil particles in a soil mass (Brady and Weil, 2004). On the majority of the area, angular to sub angular blocky structured soil was observed.

Soil reaction (pH):-

Soil reaction (usually expressed as pH value) is the degree of soil acidity or alkalinity, which is caused by particular chemical, mineralogical and/or biological environment. Soil reaction affects nutrient availability and toxicity, microbial activity, and root growth. The pH of soil was ranged from 4.42 to 5.67 with the mean value of 5.03 (Table 4). The results have shown that soil pH was very acidic (Figure 4). Soils having pH 6.0-7.5 is ideal for their proper growth and development oilseed crops. The very acidic pH reduces availability of most of the plant essential nutrients (Havlin et al., 2010). Therefore, periodically agricultural lime incorporation is imperative for amelioration of soil acidity. The soil reaction showed low variability (5.12%) among the soil samples.

Table 4. Soil fertility status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Descriptive Statistics	Soil Fertility Parameters				
	pH	OM	N	P_2O_5	K_2O
		%		ppm	
Mean	5.03	2.02	0.10	51.83	128.97
Median	5.04	1.98	0.10	49.07	114.60
StDev	0.26	0.66	0.02	28.83	51.91
SE Mean	0.04	0.11	0.001	4.68	8.42
Minimum	4.42	0.24	0.05	5.86	69.60
Maximum	5.67	3.26	0.13	113.28	255.60
CV%	5.12	32.49	19.51	55.62	40.25

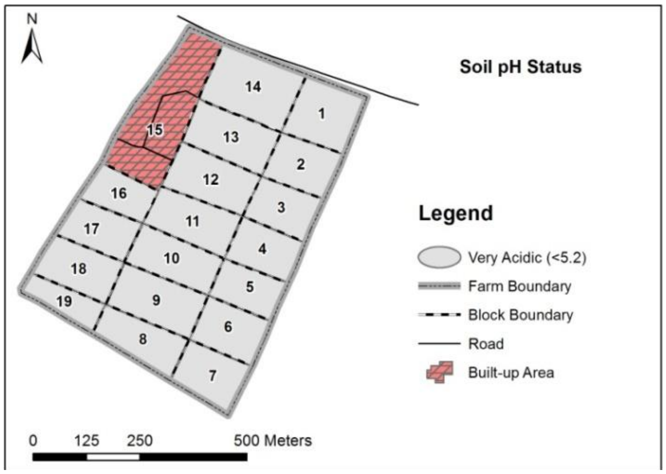

Figure 4:- Soil pH status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Soil organic matter:-

Soil organic matter is important to make soil alive. It plays significant role for various functional activities in soils. The organic matter content was varied from 0.24 to 3.26% with an average value of 2.02% (Table 4). It indicates that the organic matter content was medium (Figure 5; Table 7). Organic matter showed moderate variability (32.49%) in the investigated soil samples.

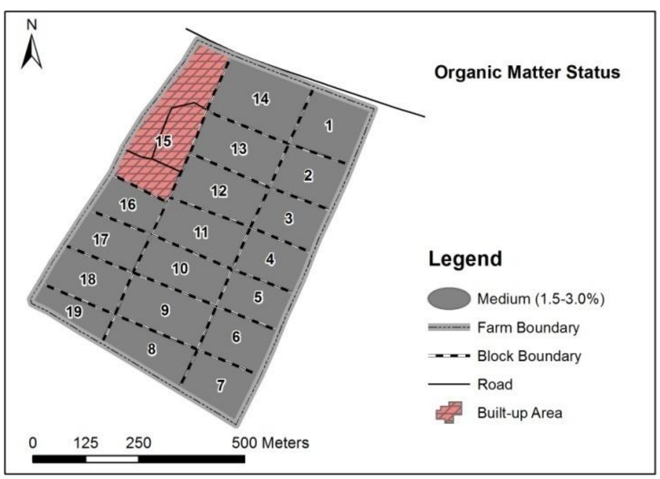

Figure 5:- Organic matter status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Total nitrogen:-

Nitrogen is the fourth most plant nutrient required highly by plants after carbon, oxygen and hydrogen, but it is one of the most deficient elements in the tropics for crop production (Mesfin, 1998). It is a substrate needed for the synthesis of amino acids and proteins which are constituents of protoplasm and chloroplast (Singh, 1996). The total nitrogen content was ranged from 0.05 to 0.13% with an average value of 0.10% (Table 4). This indicates medium status of total nitrogen (Figure 6; Table 7). Low variability (19.51%) in total nitrogen was observed among the sampled soils.

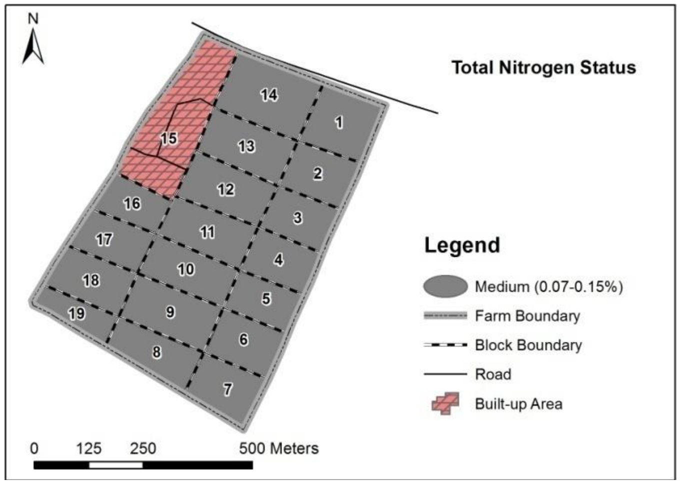

Figure 6:- Total nitrogen status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available phosphorus:-

Phosphorus is known as the master key to agriculture because lack of available P in the soils limits the growth of both cultivated and uncultivated plants (Foth and Ellis, 1997).The available phosphorus was ranged from 5.86 to 113.28 ppm with the mean value of 51.83 ppm (Table 4). This showed high status of available phosphorus (Figure 7; Table 7). The variation in the available phosphorus of the soil is high, with coefficients of variation of 55.62%.

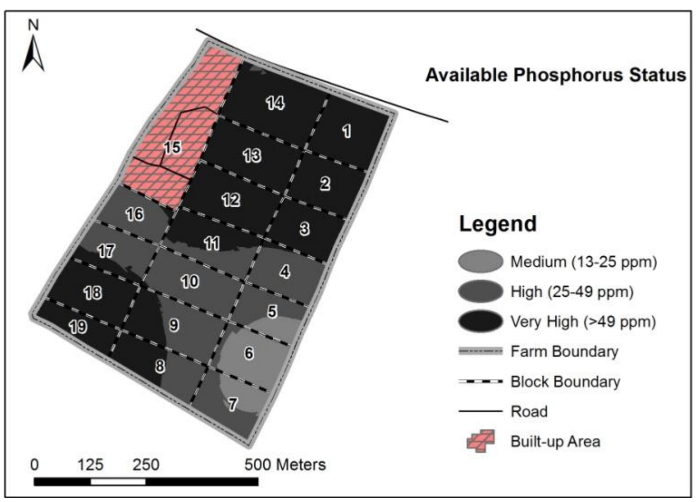

Figure 7:- Available phosphorus status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Extractable potassium

Potassium is the third most important essential element next to N and P that limit plant productivity. It is one of the important elements for the development of the plant (Schoenholtz, 2000). The extractable potassium content was ranged from 69.6 to 255.6 ppm with an average value of 128.97 ppm (Table 4). This indicates high status of extractable potassium (Figure 8; Table 7). Moderate variability (40.25%) in extractable potassium was observed among the soil samples.

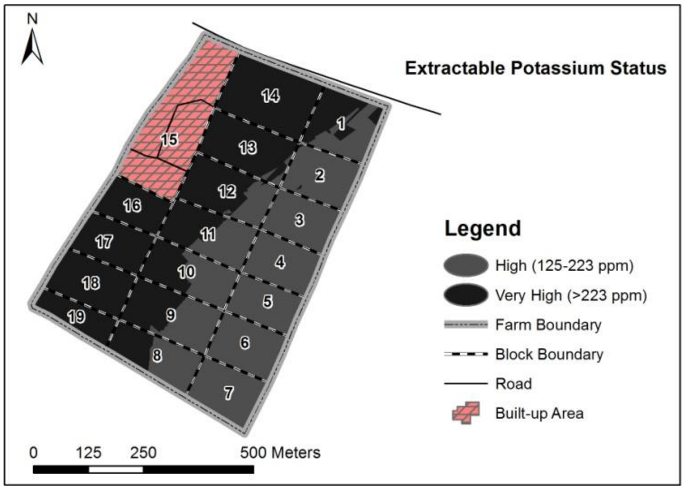

Figure 8:- Extractable potassium status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Table 5:- Soil fertility status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Descriptive Statistics	Soil Fertility Parameters			
	Ca	Mg	S	B
	ppm			
Mean	697.89	109.89	2.15	1.24
Median	710.00	90.00	2.26	1.20
StDev	184.93	81.46	1.17	0.53
SE Mean	30.00	13.21	0.19	0.09
Minimum	180.00	12.00	0.05	0.26
Maximum	1060.00	432.00	4.03	2.50
CV%	26.5	74.13	54.16	42.82

Extractable calcium:-

Calcium plays a pre-dominant role in the composition of cell wall and protoplasm. It has been associated with carbohydrates and various organic acids (Mahajan and Billore, 2014). The extractable calcium content was ranged from 180 to 1060 ppm with an average value of 697.89 ppm (Table 5). In overall, low status of extractable calcium was observed (Figure 9; Table 7). Therefore, to make calcium adequate in the soils, soil reaction should be managed first as soon as possible. Moderate variability (26.5%) in extractable calcium was observed among the soil samples.

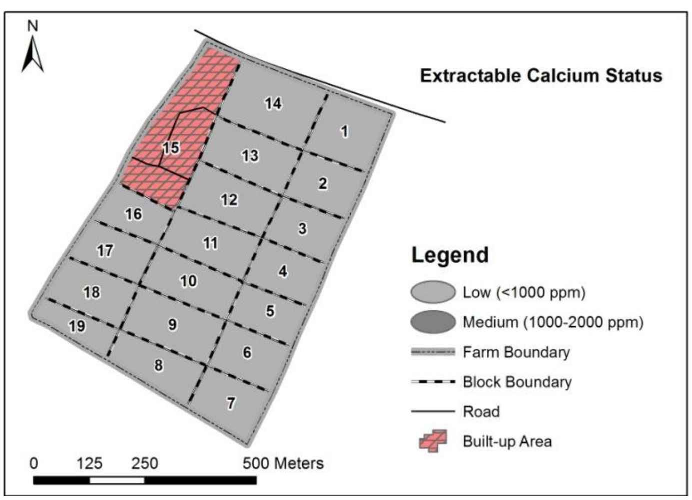

Figure 9:- Extractable calcium status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Extractable magnesium:-

Magnesium is a water soluble Cation and it is necessary for chlorophyll pigment in green plants (Mahajan and Billore, 2014). The extractable magnesium content was ranged from 12 to 432 ppm with the mean value of 109.89 ppm (Table 5). This revealed medium content of extractable magnesium (Figure 10; Table 7). The variation in the extractable magnesium of the soil is high, with coefficients of variation of 74.13%.

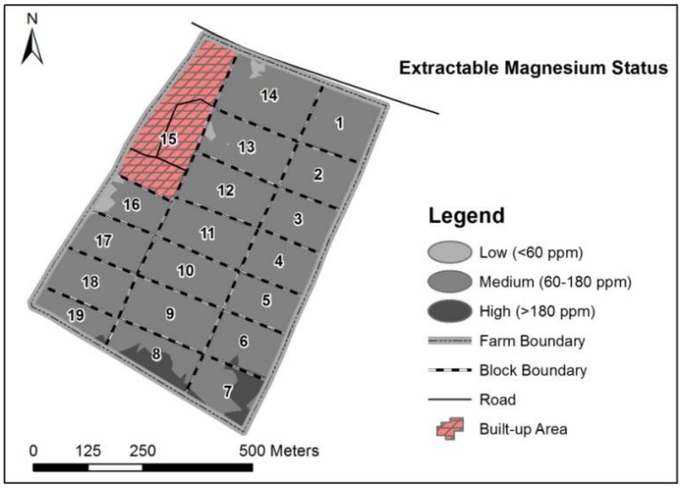

Figure 10:- Extractable magnesium status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available sulphur:-

Sulphur is an essential plant nutrient and plays a vital role in the synthesis of amino acids (methionine, cystein and cystine), proteins, chlorophyll and certain vitamins (Zhao et al., 1997; Havlin et al., 2010; Tiwari and Gupta, 2006). Sulphur is very important nutrient for oilseed crops. The available sulphur was varied from 0.05 to 4.03 ppm with an average value of 2.15 ppm (Table 5). In overall, available sulphur was low in status (Figure 11; Table 7). Therefore, regularly sulphur rich organic and inorganic source of materials should be incorporate. Available sulphur showed high variability (54.16%) in the soil samples.

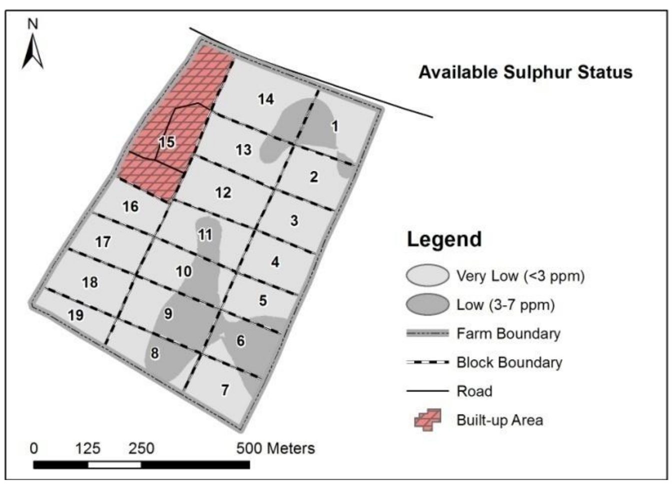

Figure 11:- Available sulphur status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available boron:-

Boron is one of two nonmetal micronutrients required by plants for their cell wall structural integrity (Havlin et al., 2010). The available boron content was ranged from 0.26 to 2.50 ppm with a mean value of 1.24 ppm (Table 5). This indicates medium content of available boron (Figure 12; Table 7). Moderate variability (42.82%) in available boron was observed among the soil samples.

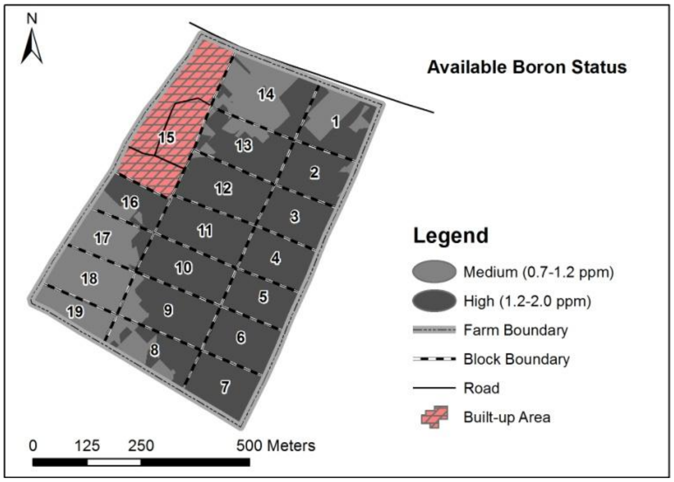

Figure 12:- Available boron status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Table 6:- Soil Fertility Status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Descriptive Statistics	Soil Fertility Parameters			
	Fe	Zn	Cu	Mn
	ppm			
Mean	107.2	0.92	0.92	13.53
Median	96.5	0.97	0.9	12.05
StDev	64.6	0.41	0.28	6.27
SE Mean	10.5	0.07	0.05	1.02
Minimum	4.4	0.22	0.38	5.18
Maximum	262.9	1.7	1.5	30.22
CV%	60.22	44.43	30.31	46.32

Available iron:-

Iron is the fourth most abundant element, comprising about 5% of the earth's crust. In plants, it functions both as a structural component and as a co-factor for enzymatic reactions (Das, 2000). The available iron content was ranged from 4.4 to 262.9 ppm with the mean value of 107.2 ppm (Table 6). This indicates very high content of available iron (Figure 13; Table 7). Available iron showed high variability (60.22%) among the soil samples.

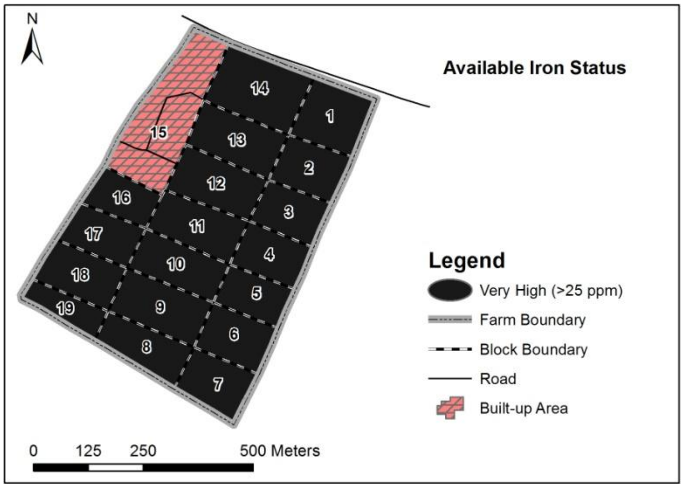

Figure 13:- Available iron status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available zinc:-
Zinc is one of the eight trace elements which are essential for the normal healthy growth and reproduction of crop plants (Alloway, 2008). The available zinc was varied from 0.05 to 4.03 ppm with an average value of 2.15 ppm (Table 6). In overall, available zinc was medium in status (Figure 14; Table 7). The available zinc showed moderate variability (44.43%) among the soil samples.

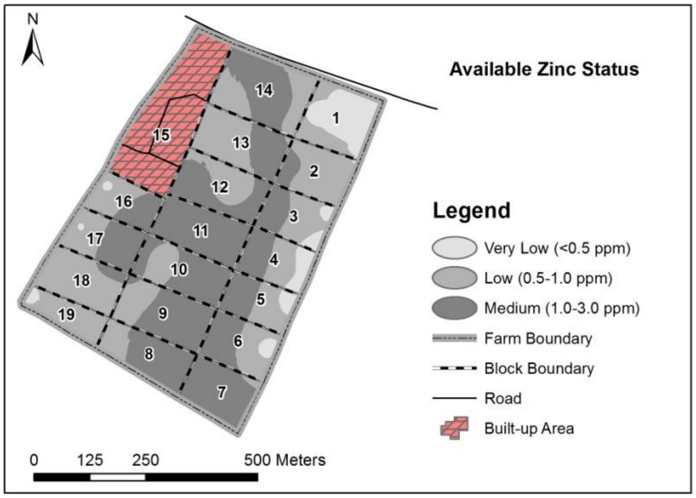

Figure 14:- Available zinc status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available copper:-
Copper is one of the oldest known metals. It is the 25th most abundant element in the Earth's crust. The available copper content was ranged from 0.38 to 1.5 ppm with the mean value of 0.92 ppm (Table 6). This revealed medium status of available copper (Figure 15; Table 7). Moderate variability (30.31%) in available copper was observed among the soil samples.

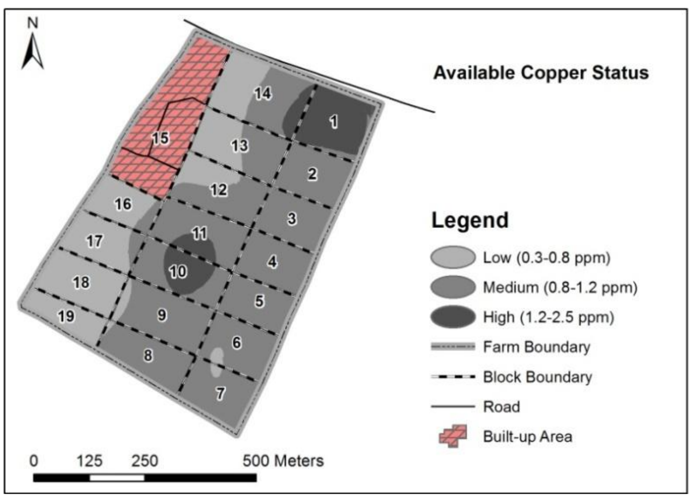

Figure 15:- Available copper status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Available manganese:-
Manganese is the 10th most abundant element on the surface of the earth. It is involved in many biochemical functions, primarily acting as an activator of enzymes such as dehydrogenases, transferases, hydroxylases, and decarboxylases (Graham, 1983; Burnell, 1988). The available manganese content was ranged from 5.18 to 30.22 ppm with an average value of 13.53 ppm (Table 6). This indicates high content of available manganese (Figure 16; Table 7). The available manganese showed moderate variability (46.32%) among the soil samples.

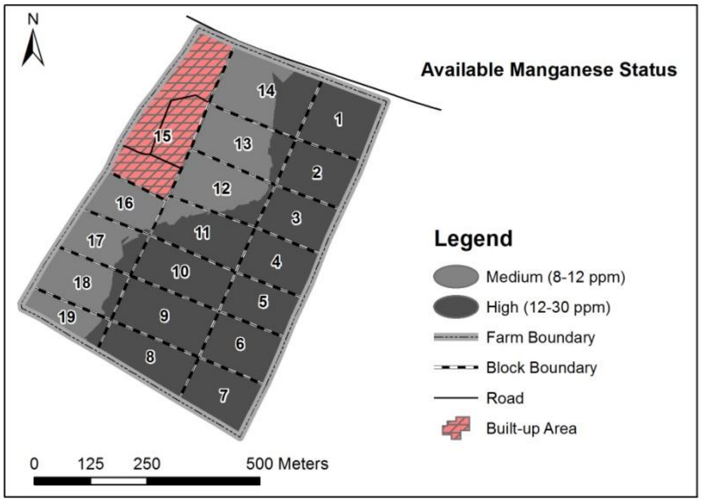

Figure 16:- Available manganese status of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

Table 7:- Nutrient index of studied parameters of Oilseed Research Program, Nawalpur, Sarlahi, Nepal

S.N.	Parameters	% Samples category			Nutrient Index	Remarks
		Low	Medium	High		
1.	OM	13.2	78.9	7.9	1.95	Medium
2.	N	5.3	94.7	-	1.95	Medium
3.	P_2O_5	2.6	18.4	78.9	2.76	High
4.	K_2O	-	73.7	26.3	2.26	Medium
5.	Ca	94.7	5.3	-	1.05	Low
6.	Mg	28.9	55.3	15.8	1.87	Medium
7.	S	100	-	-	1.0	Low
8.	B	10.5	39.5	50.0	2.39	High
9.	Fe	2.6	2.6	94.7	2.92	High
10.	Zn	52.6	47.4	-	1.47	Low
11.	Cu	34.2	52.6	13.2	1.79	Medium
12.	Mn	13.2	36.8	50.0	2.37	High

Conclusion:-

In overall, the soil structure was angular to sub-angular blocky and varied between brown, yellowish brown and dark grayish brown in colour. The soil was very acidic in reaction and requires application of agricultural lime periodically. The calcium, sulphur and zinc status were low. The organic matter, nitrogen, magnesium and copper status were medium. The phosphorus, potassium, boron and manganese status were high. The iron status was very high. For enhancing research efficacy of the oilseed crops, future research strategy should be built based on the soil fertility status of the farm.

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