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Assesment of soil fertility status of vegetable super zone, Kaski

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Abstract
Soil is the living and breathing skin of the planet earth. Essentially, all life depends upon soil and there can be no life without soil and no soil without life. Nepal has predominantly been an agricultural country and 66% of the total population are dependent on agriculture and allied activities for their livelihood. In order to remain food secured and for enhancing production and productivity of food and vegetable crops, the Government of Nepal has created Blocks, Zone and Super zone for particular crop depending on the suitability of the crop according to agro ecological zones. This research aims to assess and prepare soil nutrient map of Vegetable super zone, Kaski in Nepal. The specific objectives of the research were to assess soil texture, pH and organic matter status and simultaneously prepare soil fertility map of the vegetable super zone. A total of 202 soil samples were collected and nutrients were analysed using standard procedure in the soil laboratory. Composite soil samples were collected from 6 to 10 different spots of the area at 0-20 cm depth by using soil auger. The GPS location of each soil sampling point was noted. The soil sampling point of each zone was determined by studying various aspects (area, slope, colour, texture, etc.) of the study area. Based on the nutrient status, nutrient maps were prepared and presented. Soil fertility maps were prepared by observing the critical nutrients required for the specific crops and by giving those nutrients certain ranking based on the nutrients role for the crop. Results revealed that soil of Pokhara Lekhnath Mahanagarpalika was mostly found to be neutral in reaction (mean pH 6.68), low to high organic matter and total nitrogen, very low to very high available phosphorus and potassium. Boron content of the soil ranged from 0.2 to 7.66 ppm ranging from low to high. Majority of the soils of study area is silty loam. There are also sandy loam and loam types of soil in the area. Based on the soil analysis report, it could be concluded that the soils of Pokhara Lekhnath Mahanagarpalika is fair enough for cultivating vegetable crops at the moment but may have severe problem of Phosphorus, Boron and potassium nutrients in the some soil of the area. Soil fertility maps were prepared by setting criteria based on nutrient status that were tested in the laboratory and on the basis of nutrients that are critical for each crops of the super zones. Vegetable super zone soil was found having high fertility status (68%).

Keywords: Soil fertility map, vegetable super zone, soil nutrients, etc

Introduction
Soil is the living and breathing skin of the planet earth. Soil is the result of the interaction between the atmosphere, biosphere and the geosphere. Essentially, all life depends upon soil and there can be no life without soil and no soil without life. They evolve together and are interdependent. Soils provide many critical ecological services such as clean water, nutrient cycle regulation and hydrological cycle moderation. They are the greatest pool of terrestrial organic carbon, contain one quarter of global biodiversity and provide a habitat for seed dispersion and dissemination of the gene pool. Soils are fundamental to life on Earth. They constitute the foundation of agricultural development and ecological sustainability and constitute the basis for food, feed, fuel and fibre production.

Nepal has predominantly been an agricultural country and 66% of the total population are dependent on agriculture and allied activities for their livelihood (MOAD, 2015) [8]. In order to remain food secured and for enhancing production and productivity of food and vegetable crops, the Government of Nepal has created Pockets, Blocks, Zones and Super zones for particular crops depending on the suitability of the crops according to agro ecological zones. At present, there are eight super zones in Nepal out of these vegetable super zone were selected for the soil fertility mapping. The performance of the crops depends on the physical, chemical and biological properties of soil. Soil reaction determines the availability of nutrients to the crops and crops have their specific nutrient requirements. Thus, studying and mapping of nutrient status is essential to judge the nutrient requirement and application of nutrients for the sustainable management of crop and soil health.

Horticultural crops are the major sector of Nepalese agriculture. Horticulture contributes about 14 percent to the total agricultural gross domestic products (AGDP) (Thapa, 1998) [12].

The share of horticulture to the AGDP has increased in recent years. By realizing the importance and role of horticulture, the Agriculture Perspective Plan (APP) has targeted the growth rate of horticulture GDP to 5.5 percent per annum by 2014/2015 and growth rate of vegetable GDP in particular to 5.42 percent per annum. Among the horticultural crop, the vegetable sector is has the most significant contribution to total horticultural GDP. At present, more than two hundred vegetable species are grown in the different climatic zones of Nepal, out of which fifty species and their varieties are grown on the commercial basis (Shrestha *et al*., 2004) [10]. In 2009/2010, production of vegetable was 3,003,821 MT from an area of 235,098 ha at an average yield of 12.77 MT/ha (MOAC, 2010) [7].

Soil Fertility management is one of the important task for food security and livelihood improvement of the local farmers. Soil is the sources for plant Nutrients supply and habitat for plants growth and development. Soil properties such as physical, chemical, and biological properties affect the plant growth and development. Different Crops require different types of soil and nutrients for their optimum yield. Therefore, it is very much important to know the exact situation of soils of the different super zones.

Soil fertility studies and mapping is an effective way to diagnose soil status and recommend as per the need of the nutrient to particular crop in the area. Mapping can help decision makers and farmers to effectively manage soil acidity, fertilizer management, organic matter management and also physical and biological maintenance of the soil. Therefore, this research aims to prepare soil nutrient map of Vegetable super zone, Kaski in Nepal. The specific objectives of the research were to assess soil texture, pH and organic matter status and simultaneously prepare soil fertility map of the vegetable super zone.

Materials and Methods

Soil sampling point determination

Identification of representative soil sampling points to collect soil samples is important for preparation efficient map of the study area. The soil sampling point of the vegetable super zone was determined by studying various aspects (area, slope, colour, texture, etc.) of the study area. Location map and soil sampling points of the super zone is shown in the Figure 1-2 below.'

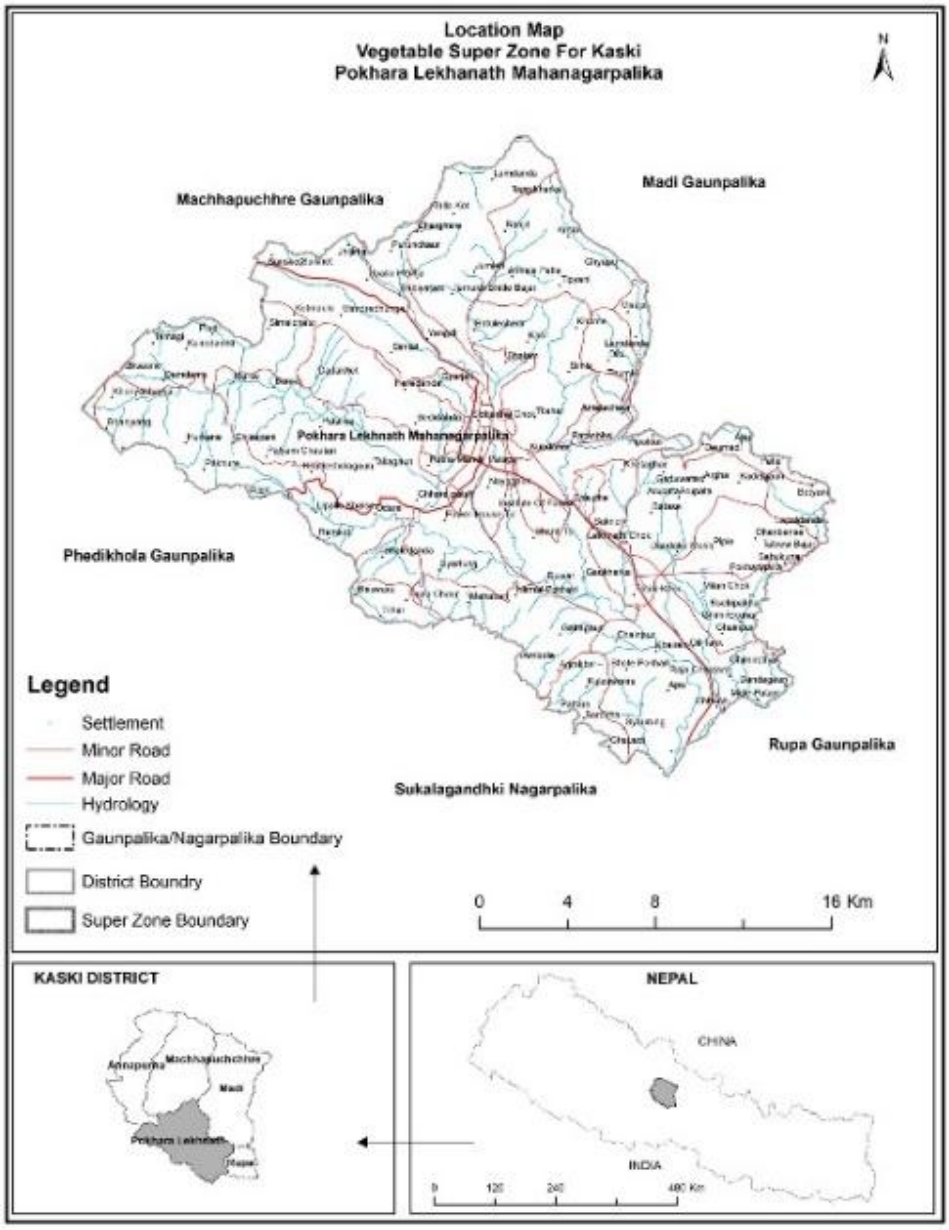

Fig 1: Location map of Vegetable super zone, Kaski

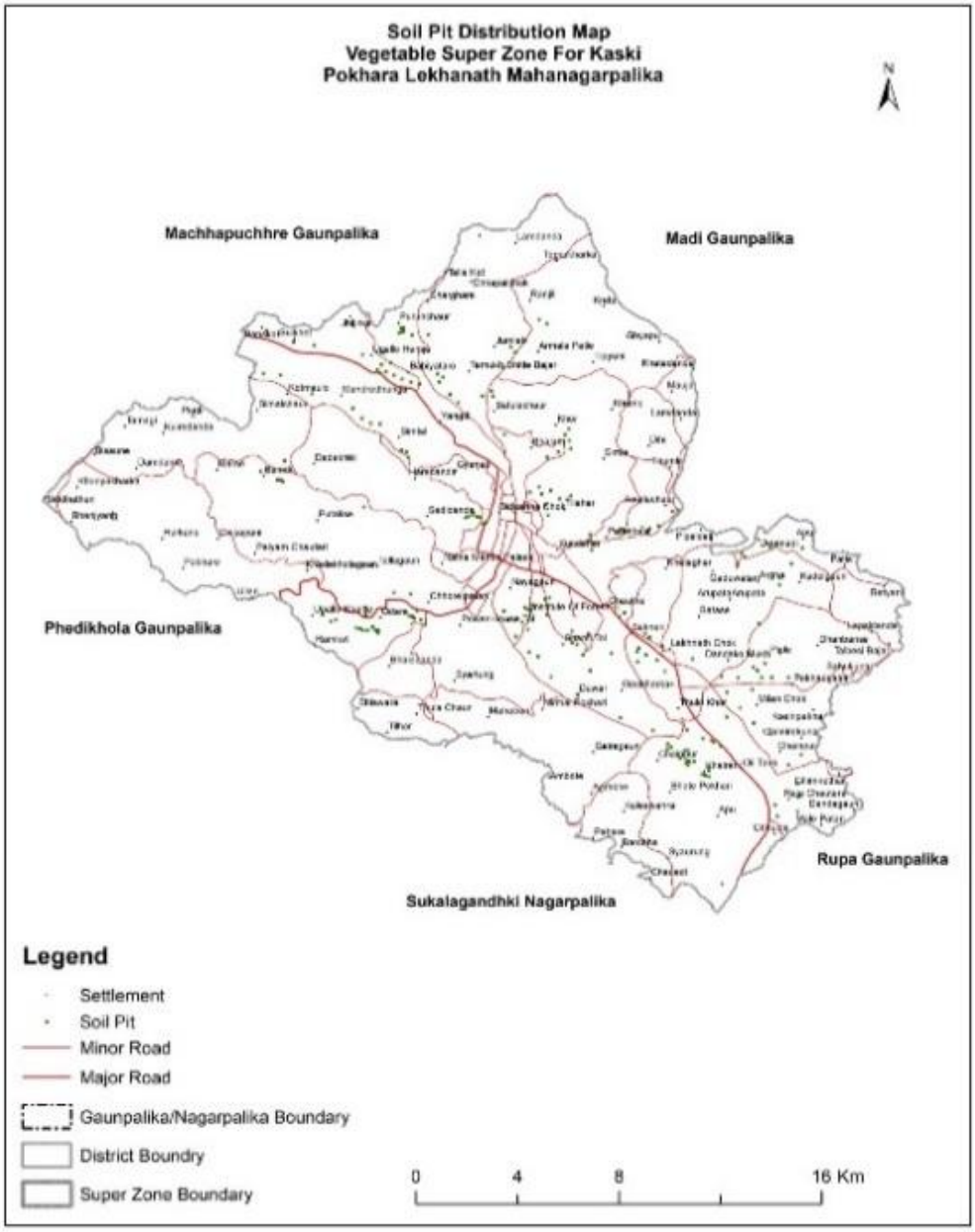

Fig 2: Soil sampling point of Vegetable super zone, Kaski

Collection and analysis of soil samples

Composite soil samples were collected from 6 to 9 different spots at 0-20 cm depth from the study area by using soil auger. A total of 202 soil samples were collected and different physical and chemical properties of soils were analyzed after bringing soil samples to the laboratory using standard procedure (Table 1).

Table 1: Methods adopted for Soil analysis in the laboratory

S.N.	Parameters	Methods
1.	Physical	
1.1	Soil Texture	Hydrometer (Bouyoucos, 1927)
2.	Chemical	
2.1	Soil pH	Potentiometric 1:2 (Jackson, 1973)
2.2	Soil organic matter (SOM)	Walkely and Black (Walkely and Black, 1934)
2.3	Macro-nutrients	
2.3.1	Total nitrogen	Kjeldahl (Bremner and Mulvaney, 1982)
2.3.2	Available P_2O_5	Modified Olsen's (Olsen *et al*., 1954)
2.3.3	Extractable K_2O	Ammonium acetate (Jackson, 1967)
2.4	Micro-nutrients (as per TOR)	
2.4.1	Available Boron	Hot water (Berger and Truog, 1939)

Preparation soil fertility maps

Latitude (Lat) and Longitude (Long) were recorded by GPS fom soil sampling points. Latitude, longitude and laboratory data were entered into excel and linked to Arc GIS 10.1 software for making soil fertility maps of respective super zones. The interpolation method employed was ordinary

kriging. Based on the data obtained from laboratory soil analysis, all nutrient maps were prepared. Soil fertility maps were prepared by setting criteria based on nutrient status (as described by Khadka, 2069) [11] that were tested in the laboratory and on the basis of nutrients that are critical for vegetables. For vegetables, the nutrient ranking for fertility map preparation was 3 for organic matter, 2 for N, 1.5 for Boron and 1 each for P and K.

Statistical Analysis

Summary statistics of the data obtained was computed using R software and presented for each parameter studied.

Results and Discussion

The total area of the Pokhara Lekhnath Mahanagarpalika (vegetable super zone) is 46423.53 ha and the total area of Kaski district is 208437.55 ha. Area covered by Vegetable super zone is given in the Table-2 below.

Table 2: Area covered by Vegetable Super zone in hectare and percentage

S.N	Ward. No.	Nagarpalika	Area in hectare	Percentage
1	4	Pokhara Lekhnath Mahanagarpalika	50.97	0.11
2	2	Pokhara Lekhnath Mahanagarpalika	60.04	0.13
3	3	Pokhara Lekhnath Mahanagarpalika	63.40	0.14
4	9	Pokhara Lekhnath Mahanagarpalika	122.27	0.26
5	12	Pokhara Lekhnath Mahanagarpalika	139.91	0.30
6	1	Pokhara Lekhnath Mahanagarpalika	154.31	0.33
7	8	Pokhara Lekhnath Mahanagarpalika	176.22	0.38
8	5	Pokhara Lekhnath Mahanagarpalika	178.15	0.38
9	10	Pokhara Lekhnath Mahanagarpalika	195.53	0.42
10	7	Pokhara Lekhnath Mahanagarpalika	197.29	0.42
11	29	Pokhara Lekhnath Mahanagarpalika	421.72	0.91
12	15	Pokhara Lekhnath Mahanagarpalika	511.82	1.10
13	6	Pokhara Lekhnath Mahanagarpalika	632.54	1.36
14	11	Pokhara Lekhnath Mahanagarpalika	696.80	1.50
15	17	Pokhara Lekhnath Mahanagarpalika	788.91	1.70
16	30	Pokhara Lekhnath Mahanagarpalika	940.17	2.03
17	19	Pokhara Lekhnath Mahanagarpalika	1103.61	2.38
18	26	Pokhara Lekhnath Mahanagarpalika	1213.41	2.61
19	27	Pokhara Lekhnath Mahanagarpalika	1223.01	2.63
20	14	Pokhara Lekhnath Mahanagarpalika	1336.36	2.88
21	19	Pokhara Lekhnath Mahanagarpalika	1349.35	2.91
22	32	Pokhara Lekhnath Mahanagarpalika	1500.63	3.23
23	13	Pokhara Lekhnath Mahanagarpalika	1537.66	3.31
24	28	Pokhara Lekhnath Mahanagarpalika	1757.48	3.79
25	18	Pokhara Lekhnath Mahanagarpalika	1776.60	3.83
26	24	Pokhara Lekhnath Mahanagarpalika	1850.05	3.99
27	25	Pokhara Lekhnath Mahanagarpalika	2238.36	4.82
28	20	Pokhara Lekhnath Mahanagarpalika	2294.08	4.94
29	31	Pokhara Lekhnath Mahanagarpalika	2446.05	5.27
30	22	Pokhara Lekhnath Mahanagarpalika	3210.64	6.92
31	16	Pokhara Lekhnath Mahanagarpalika	3468.33	7.47
32	21	Pokhara Lekhnath Mahanagarpalika	3590.29	7.73
33	33	Pokhara Lekhnath Mahanagarpalika	4417.98	9.52
34	23	Pokhara Lekhnath Mahanagarpalika	4779.60	10.30
Total			46423.53	100.00

Soil Reaction

Soil pH is important because a soil's acidity or alkalinity determines what plant nutrients are available to plant roots. Nutrients in the soil elements such as nitrogen, phosphorus, and potassium become available to plants when they dissolve in water or soil moisture. Most plant nutrients will not dissolve when the soil is either too acidic or too alkaline.

The soil reaction of Pokhara Lekhnath Mahanagarpalika was mostly found to be Neutral (Table-3). Mean soil reaction of the area is 6.68 that fall under the category of neutral, which is almost very suitable for all the crops (fig. 3). Almost all soils of Pokhara Lekhnath Mahanagarpalika were within the neutral range that is very suitable for most of the crops. The soil pH ranged from 4.7 to 7.8, but most of the samples showed neutral reaction where almost all major and micronutrients will be in available form. Vegetables and most food crops can be grown in such type of soil. Only few samples showed highly acidic reaction and in such type of soil, liming should be done. Vegetables and other plants grow best when the soil pH is optimal for the plants being grown. It is important to match a plant to the soil pH or to adjust the soil pH to a plant's needs.

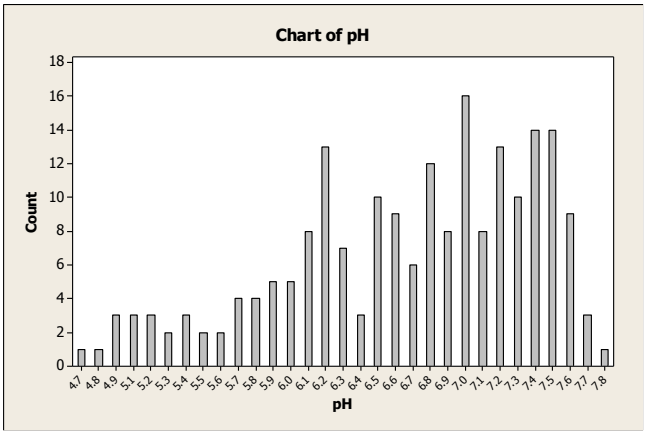

Fig 3: pH count chart of the study area

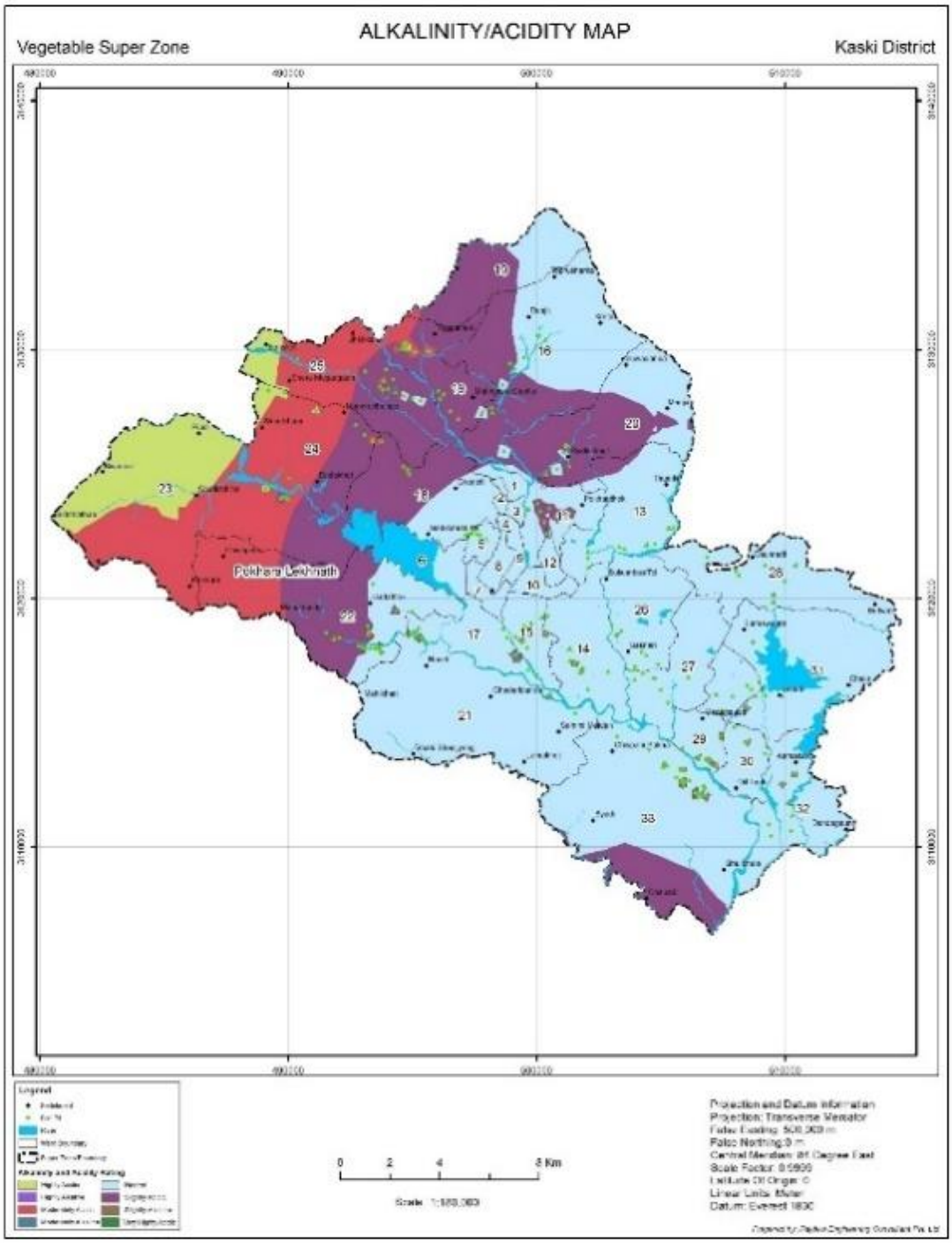

Fig 4: Soil Reaction map of Vegetable super zone, Kaski

Table 3: Descriptive Statistics of the Vegetable Super zone on different soil variables

Variable	Mean	SE Mean	St Dev	COV	Min	Max	Range
pH	6.68	0.05	0.72	10.79	4.7	7.8	3.1
Organic Matter (%)	6.0	0.15	2.13	35.51	1.35	9.6	8.25
Total Nitrogen (%)	0.24	0.006	0.09	37.83	0.08	0.61	0.53
Available Potassium (Kg/ha)	239.7	17.9	254.3	106.12	0.00	1980.1	1980.1
Clay %	6.877	0.170	2.419	35.18	2.100	22.100	20.0
% Sand	39.752	0.788	11.198	28.17	10.90	73.05	62.15
% Silt	53.371	0.778	11.052	20.71	22.00	79.00	57.0
Boron, (µg/g)	1.92	0.0878	1.2484	65.01	0.20	7.66	7.46

Organic Matter content

The organic matter content of the soil ranged from 1.35% to 9.6%, ranging from low to high. Mean organic matter content of the sampled soil is 6% which falls under the category of high. Most of the soils of Pokhara Lekhnath Mahanagarpalika are under the category of high organic matter content. Organic matter is the heart of the soil and it plays vital role in crop performance and maintaining soil health. Arresting the fall of soil organic matter in the area will be one of the key to maintain better soil status.

Total Nitrogen content

Total nitrogen in the soils of area falls within the range of 0.08 to 0.53% that are under the category of low to very high.

Mean N content is 0.24% that falls under the category of very high. Presence of Organic matter in the soil is closely related with the amount of total N in the soil. Both parameters in the soils are within high category. The Soil properties and nutrient content were found similar to the Soil Management Report 2074 (SMD, 2017 and SSD, 2017). Care should be taken to grow crops with ample incorporation of organic manure in the area with low organic matter content and nitrogen.

Available Phosphorus content

Available phosphorus of the soils, in general falls within wide range and depending upon the soil types. It falls within the range of 8 to 182 kg per hectare in the category of very low to very high. Mean Phosphorus content of the soil is in medium range. There is wide variation of available phosphorus content in the soil.

Available Potssium content

The amount of available potassium in the soils of Pokhara Lekhnath Mahanagarpalika ranges from 0 to 1980 kg per hectare falling under the category of very low to very high. The mean value of the available potassium in the soil is 240 kg per hectare that falls under the category of medium. Critical level of available potassium was seen in some area. Immediate attention to apply potassium should be given at the earliest. Otherwise, there can be crop failure in such area.

Available Boron content

Boron content of the soil ranged from 0.2 to 7.66 ppm ranging from low to high. Borax should be added to the soil with low boron content.

Soil Texture

Majority of the soils of study area is silty loam. There are also sandy loam and loam types of soil in the area.

Soil Fertility Status of all the super zone

Based on the laboratory analysis of the soil, fertility of soils were categorized as very low, low, medium, high and very high. Area for each category was estimated and coverge of the category was calculated in percentage as shown in the table 4. Soil fertility maps were prepared by setting criteria based on nutrient status that were tested in the laboratory and on the basis of nutrients that are critical for each crops of the super zones. Vegetable super zone soil was found having high fertility status (68%) and medium (22%) fertile (Table 4 and figure 5). Therefore, this soil showed enough fertility for producing vegetables.

Table 4: Soil fertility statistics of Vegetable super zone, Kaski

SN	Fertility Rating	Area (Ha)	Percentage
1	High	31771.05	68.44
2	Low	3409.10	7.34
3	Medium	10331.56	22.26
4	Very High	114.94	0.25
5	Very Low	796.88	1.72
	Grand Total	46423.53	100.00

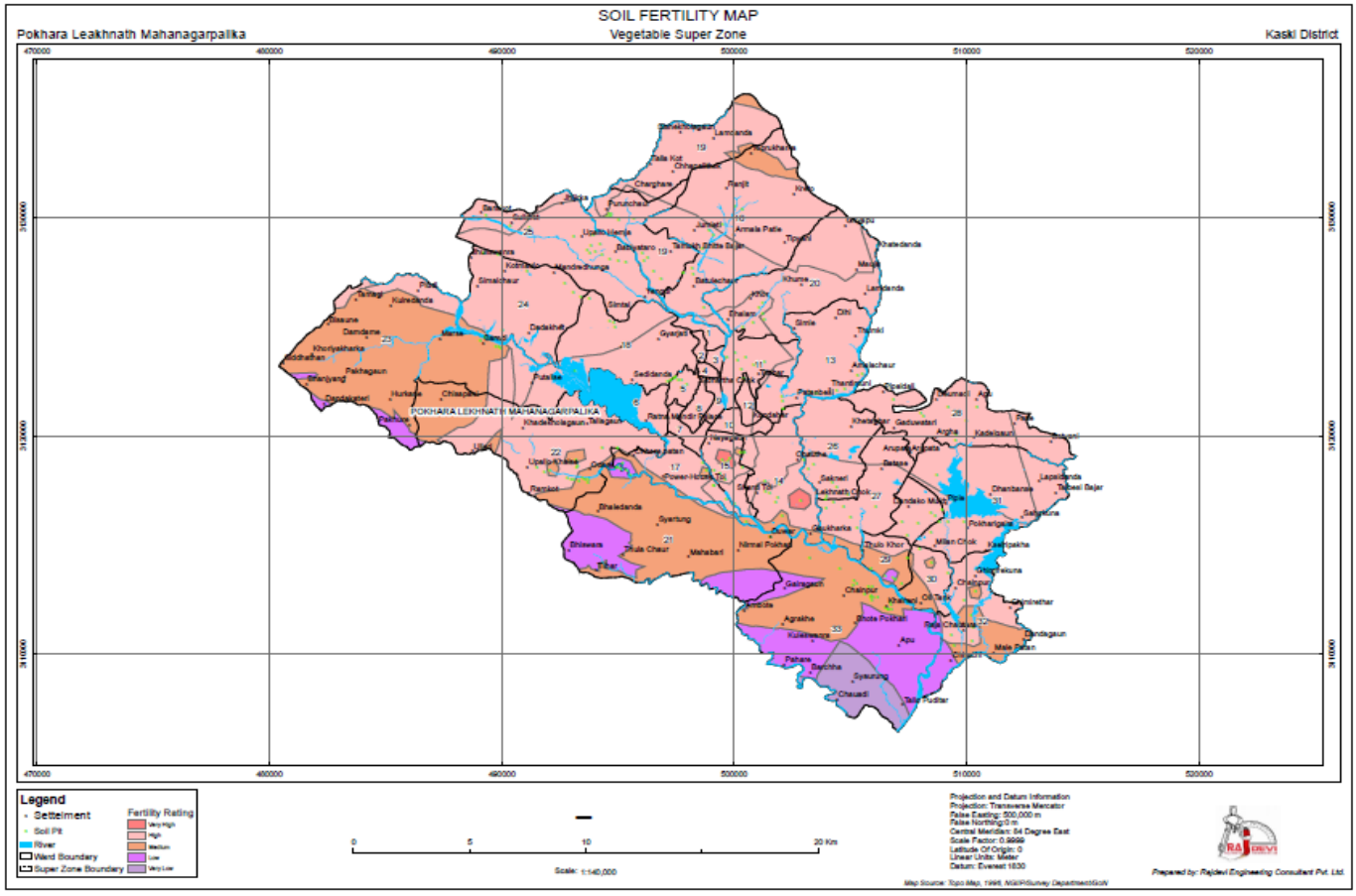

Fig 5: Soil fertility map of Vegetable super zone, Kaski

Soil Parameter maps

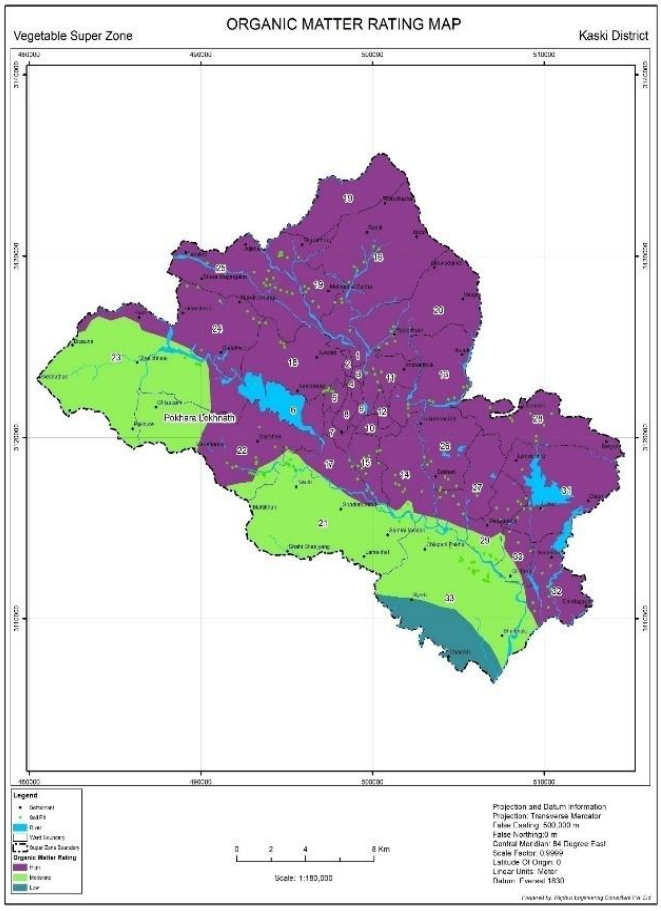

Fig 6: Soil Organic matter content map

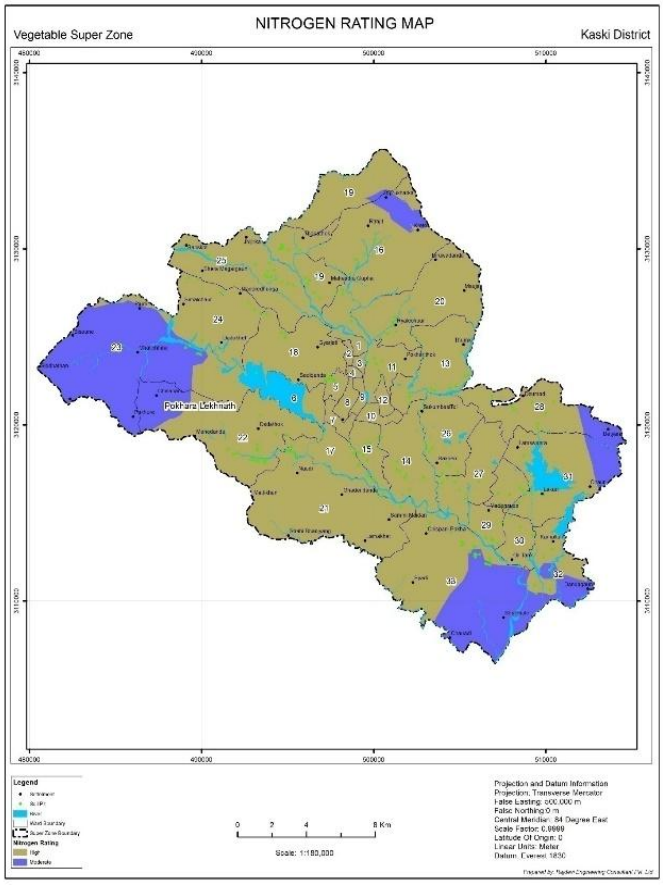

Fig 7: Total Nitrogen content map of Vegetable super zone

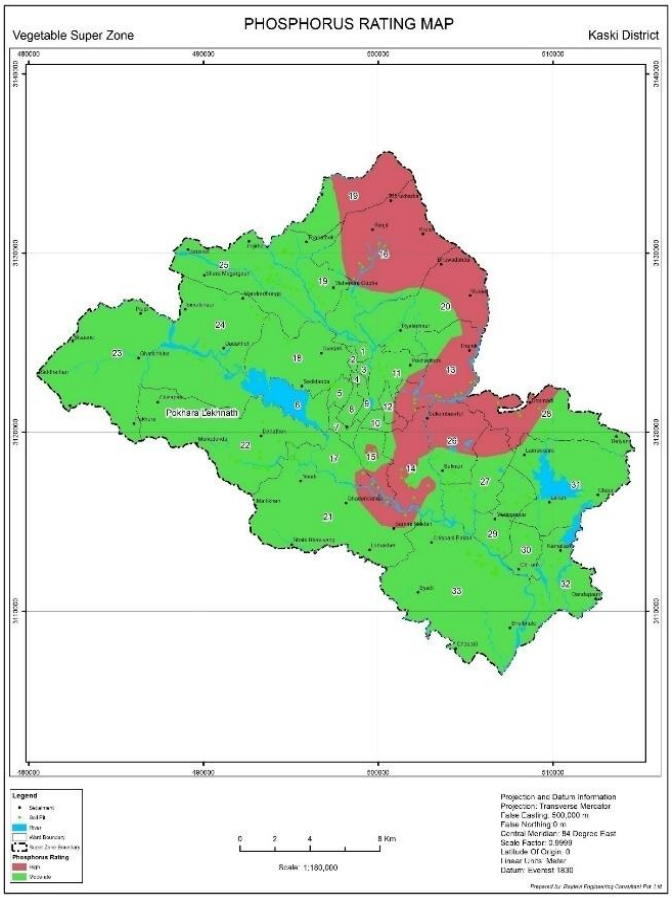

Fig 8: Available Phosphorus content map

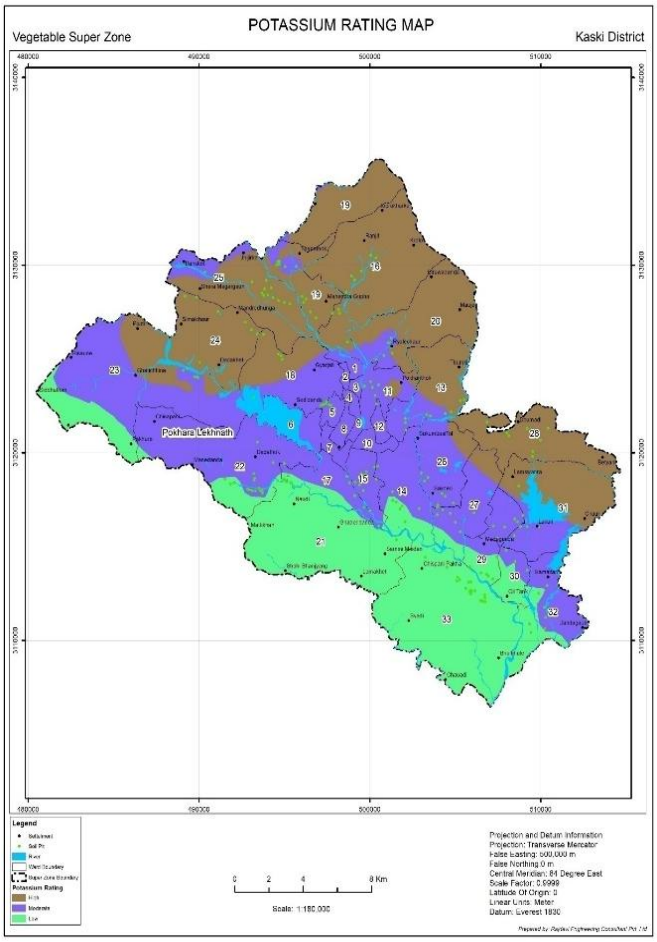

Fig 9: Available potassium content map

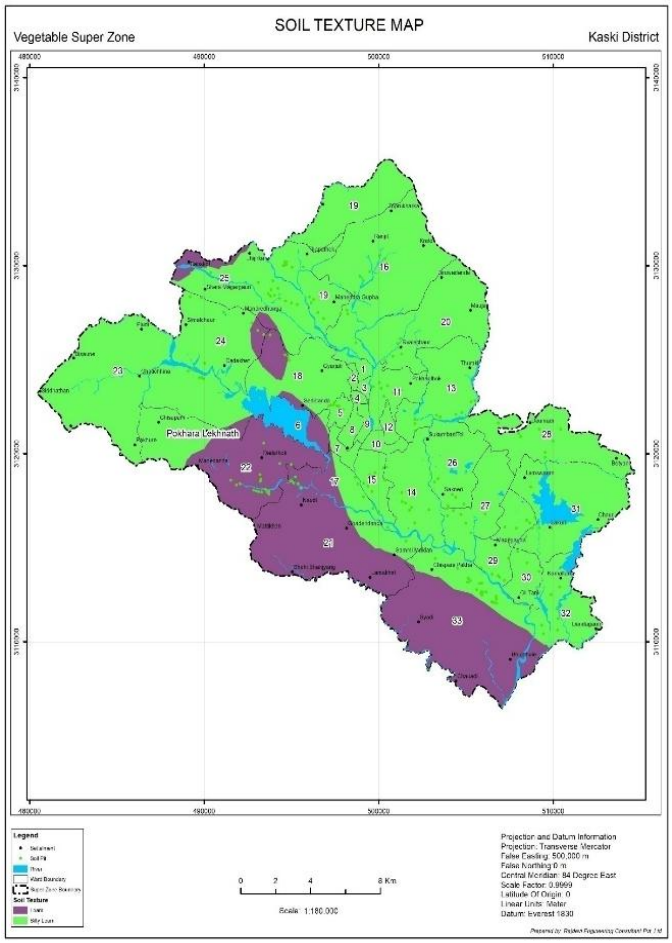

Fig 10: Soil texture map of Vegetable super zone

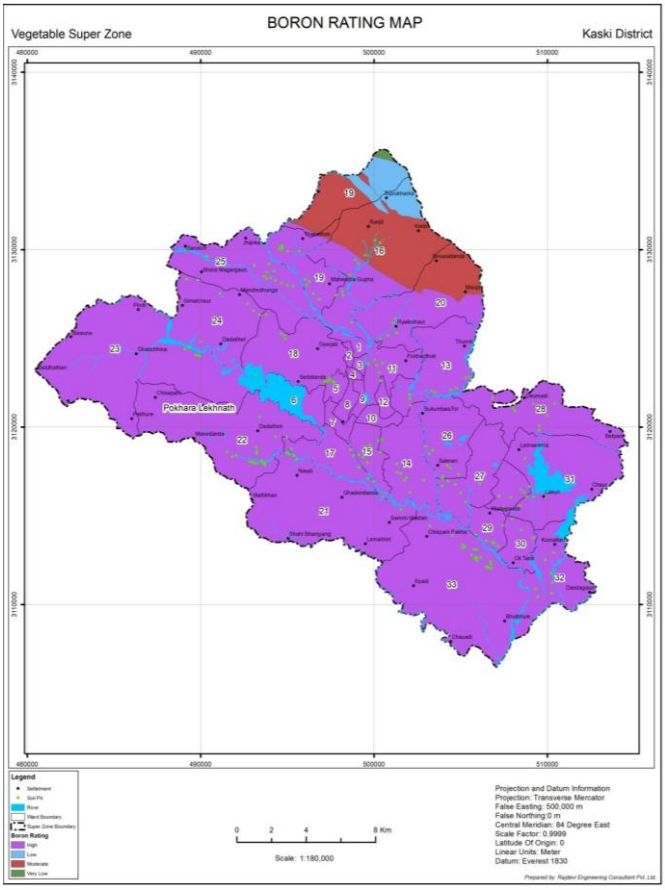

Fig 11: Boron content map of Vegetable super zone

Summary and Conclusion

Based on the soil analysis report, it could be concluded that the soils of Pokhara Lekhnath Mahanagarpalika is fair enough for cultivating vegetable crops at the moment but may have severe problem of Phosphorus and potassium nutrients in the some soil of the area. The inherent soil nutrients are readily available because of suitable soil pH but in long run the soil will be exhausted and replenishment of the soil nutrients is necessary at the moment. Based on the soil pH, it is recommended to add agricultural lime in areas with low soil pH or selection of suitable vegetable crop according to the preference of soil pH is recommended. Boron also should be applied in crucifers in case of low B content of the soil. For sustained production of the Vegetable crops in the area soil quality should be maintained through incorporation of organic matter and crops residue, introducing legume crops as an intercropping or cover crops, minimum use of chemical fertilizers and pesticides.

Based on the soil fertility ranking or fertility maps, Vegetable super zone soil was found having high fertility status (68%) and medium (22%). Therefore, it could be said that the soil of vegetable super zone is fertile enough for vegetable production.

Acknowledgement

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