TABLE OF CONTENTS

PAGE

1. Introduction

To build up a database on the soil nutrient status of the major horticultural crops in the country to develop a proper fertilizer recommendation rate for crops, soil samples were being collected from the major citrus growing areas of Tsirang and Dagana dzognkhags. Soil samples will be collected once three to five years from the same areas. The sampled households are interviewed on their soil fertility management practices and general management practices.

Dagana Dzongkhag in the west-central region is one of the major citrus growing Dzongkhags next to Tsirang Dzongkhag. Citrus is grown throughout the Dzongkhag as one of the important horticultural cash crop and therefore the major source of income for the farmers. The most intensively cultivated geogs[1]. under this Dzongkhag are Kana (4 villages), Tashiding (1 village), Tshendgang (1 village), Goshi (4 villages) and Drujaygang (4 villages)

Between 9th to 15th February 2004, the staff of National Soil Services Centre (NSSC) together with the Dzongkhag staff collected soil samples from these geogs under Dagana Dzongkhag.

2. Method

The group collected the soil samples from the farmers' fields based on the list prepared by the Extension Agent (EA). The farmers were explained about the rationale behind collecting soils samples from their fields. Soil samples were collected from the households with ten trees and above. Two composite samples (top soil and subsoil) were collected from a minimum of 8-10 sub samples each from one location or site. Soil samples were collected from the depth of 0-20 cm (for top soil) and another sample from the depth of 20-40 cm (for subsoil) using a soil auger and put in plastic bags and sealed with a rubber band. The samples were then stored in a room with the open ends and care was taken not to contaminate the soils. These samples were then re-sealed for transportation and submitted to the Soil and Plant Analytical Laboratory (SPAL) for analysis. Aspects, slope angles, altitudes and the GPS readings of the fields were also recorded in the questionnaire form. The analysis of this survey was done using SPSS 11 for windows.

3. Results and discussions

In the first half of the report, the general observations of the Dzongkhag as recorded during the survey are presented while the soil results for each village under each geog is presented in the second half of this report.

[1] Kana geog =Dolamchine, Khagochine, Nobding, Pungshi villages.
Tashiding geog = Tashiding village.
Tshedgang = Gangzure village.
Goshi geog = Upper Goshi, Lower Goshi, Baley gunge, Bitlung villages.
Drujaygang = Chirigang, Yangsibi, Pangna, Thangna villages.

3.1 Total sample households

In Dagana Dzongkhag, a total of 53 households from 14 villages covering 5 geogs were sampled. The total number of soil samples collected was 106 including both top and subsoil samples. The number of citrus trees varied from 38 to 4000 from the sampled areas. The various management practices and other site parameters in addition to the soil results are presented below.

3.2 Site description: Altitudes, slopes and aspects of the fields under citrus cultivation.

The sampled areas were located in altitude range varying from 550 m.asl to 1200 m. asl with the majority of the orchards below 1000 m. asl. Citrus orchards are located in areas with moderately sloping (slope gradient<25%) to very steep slopes (slope gradient >50%) with the majority of them on steep slopes (slope gradient 25-50%) with mostly facing southeast and southwest aspects.

3.3 Citrus yield and other management practices

The total yield varied from 2 pons[2] to a maximum of 2500 pons from this Dzongkhag with an average production of 718 pons and the average yield per acre of 351 pons. All the citrus trees are 10 years or more. The area under citrus cultivation varied from 0.3 to 13 acres with an average area of 2.7 acres.

In Dagana Dzongkhag**,** more than 50% of the farmers apply FYM to citrus at a rate of half a basket to 3 baskets per tree. In this Dzongkhag, more than 80% of the farmers tether cattle in the orchards and the tethering duration varied from three to seven nights per tree. More than 75% of the farmers do not apply any chemical fertilizer to citrus and only about 25% apply and of which about 11% of the farmers apply urea (200g per tree) while about 21% of them apply suphala (rate ranging from 200g to 3kg per tree). Fertilization is carried out from December till April. More than 83% of the farmers do not irrigate their orchards mostly due to water shortage. Only about 17% irrigate and is done either once a year (about 14%) or thrice a year (3%) and are usually done with pipe at the basins.

Among other management practices, fruit drop, leaf miner and trunk borer are some of the problems reported by the farmers. Nima Khandu of Dolamchine geog however reported no fruiting despite good flowering despite no hailstorm or other natural calamities.

[2] 1 pon = 80 nos.

3.4 Soil Results

In the soil analysis result, with the exception of soil pH, the classifications are normally categorized as very low, low, moderate, high, and very high. For fertility factors (N, P, K, micronutrients) very low and low classifications indicate a high probability for obtaining a fertilizer response; moderate classifications indicate a fertilizer response may or may not occur; high and very high classifications indicate a fertilizer response is not likely to occur. Crops need all the essential nutrients but not in equal quantities and supplying of only one nutrient i.e. unbalanced nutrient such as urea leads to rapid depletion of soil reserves of other nutrients.

Ideally, the soil should be a sandy loam or loam for citrus to do well. The soil should be more than one meter deep and should have moderately porous soil layers for good drainage. Citrus growing in poorly drained soils may become immersed in stagnant water during rainy seasons, thus inducing diseases. On the other hand, gravel soils or sandy soils (light soils) may also not be profitable, as frequent irrigation and fertilization are needed. In general, the ideal soil pH for citrus is between 5.5 and 6.5 (optimum pH) due to improved availability of most of the soil nutrients such as P, K, Mg, Cu and Fe . If the pH falls below 5.0 aluminum and manganese toxicity occur in citrus roots. A low pH can also cause deficiency of nutrients such as calcium, magnesium, phosphorus (which are easily fixed by the soil particles) and molybdenum. At higher pH levels, higher than 7.5, then citrus suffers from deficiency of other nutrients such as iron, manganese, copper and zinc.

3.4.1 Soil results of Kana geog

The soil results of each village under Kana geog is summarised as follows.

The pH of the soils of this geog is mostly within the medium (pH 5.5-6.5) range with the exception of Khagochine village and some villages of Nobding with high values (pH 6.5-7.5). In general, the nutrient requirement for citrus is of medium range although N and K requirements are high as the additional dose of potassium fertilizer is essential especially during fruit development. Dolamchine geog has high available P (>30 mg/kg) while Pungshi has low values (5-15mg/kg) and 50% each of the soils in Khagochine and Nobding have low and another 50% each in the high range. The available K of Khagochine geog and few households in Dolamchine are within the high range (200- 300 mg/kg) while Punshi, Nobding and major part of Dolamchine geogs have medium values (100-200mg/kg). *Few households in Nobding have low K values (40-100 mg/kg).* The organic matter content of these soils is within the medium (2-5%) to high range (OM% >5).

The available P and K of this geog are mostly within the medium to high range with the exception of few households in Khagochine and Nobding[3]. These figures

[3] Khagochine = Kunzang Namgay

suggest that there is a need to apply P and K containing fertilizers to improve the nutrient status of these soils with low values and also deficit K limits fruit size. The organic matter of these soils is also within the medium to high range.

The CEC of this soil is within the low (5-15 meq/100g) to medium (15-25 meq/100g) range with high to very high BS%. In soils with low CEC values, all the major macro and micronutrients may be required to attain adequate growth and yields. Coarse-textured soils lack both nutrient and water holding capacities while fine-textured soils often have structural and infiltration problems. Sandy loam is the prominent soil type of Dolamchine while silty clay loam is the dominant soil type of Pungshi. Sandy loam and loam are two soil types of Khagochine while loamy sand and silty clay loam are the major soil types of Nobding geog. All these soil types are of light to medium textured soils containing less than 50% clay, for details see the following figures.

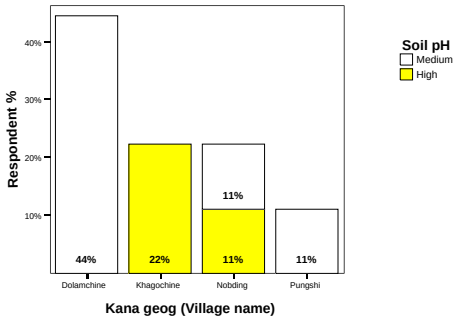

Figure 1a pH values of Kana geog .

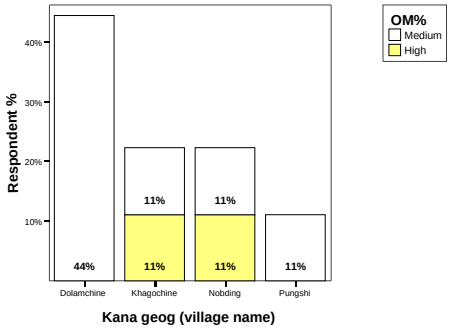

Figure 1b OM% of Kana geog .

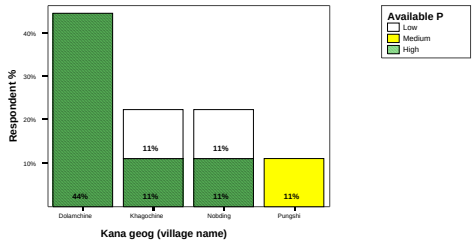

Figure 1c Available P of Kana geog .

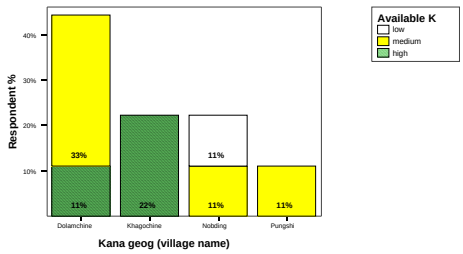

Figure 1d Available K of Kana geog

Nobding = Lhawang Norbu

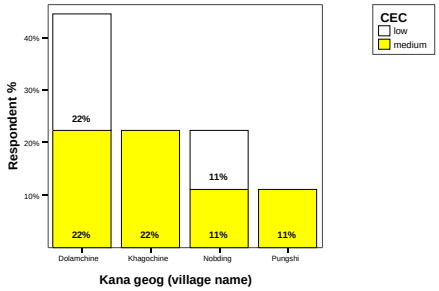

Figure 1e Cation Exchange Capacity (CEC) of Kana geog .

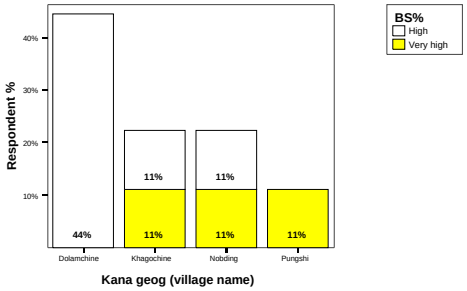

Figure 1f Base saturaition % (BS%) of Kana geog .

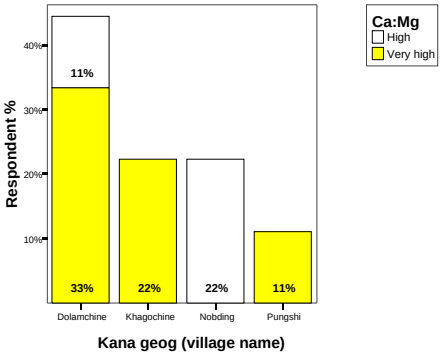

Figure 1g Calcuim : Magensium (Ca: Mg) ratio of Kana geog .

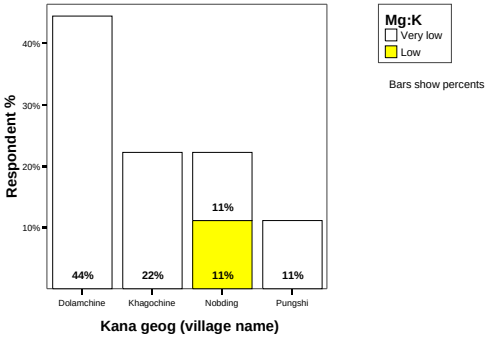

Figure 1h Magensium: Potassium (Mg:K) ratio of Kana geog .

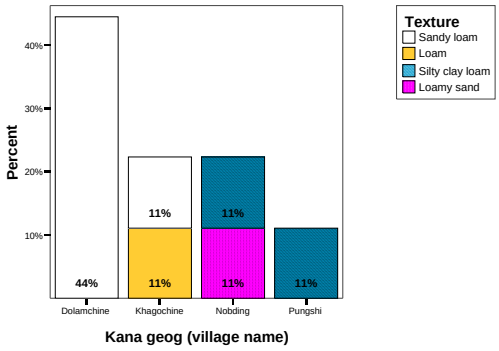

Figure 1i Soil texture of Kana geog .

3.4.2 Soil results of Goshi geog.

The pH of the soils of this geog is within the medium range. The OM% content of Bitlung is high while that of Lower Goshi and Bahleygubge is within the medium range. The available K content of this geog is mostly within the medium range with the exception of Bhaleygunge with 11% of the respondents each in the low and medium range. The available P for Bitlung and few households in Lower Goshi is very high, while the major area of Lower Goshi is within the very low-to-low range. The available P and in some cases K of this geog are mostly within the low to medium range with the exception of Bitlung. These figures suggest that there is a need to apply P and K containing fertilizers to improve the nutrient status of these soils with low values. The OM% of these soils is also within the medium to high range.

The BS% of these soils is mostly within the medium to high range while the CEC of most of these soils is within then low range with few in the medium range. The Ca:Mg ratio of Bhaleygunge is within the medium range which suggests that there is no deficit of either Ca or Mg. However, the high to very high ratios in Bitlung and parts of Lower Goshi might indicate slight deficiency of Mg while the low to very low ratio of Mg to K suggests that there is Mg deficiency in these soils. Sandy clay loam and loamy sand are the common soil types of this geog. Both these soil types are of medium textured soils containing less than 50% clay.

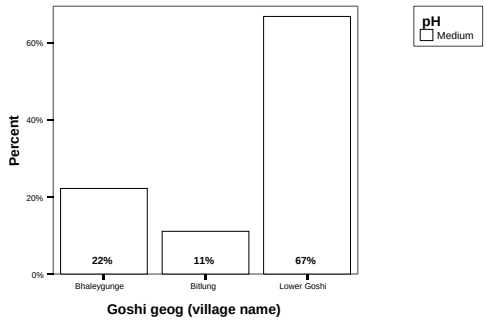

Figure 2a pH values of Goshi geog .

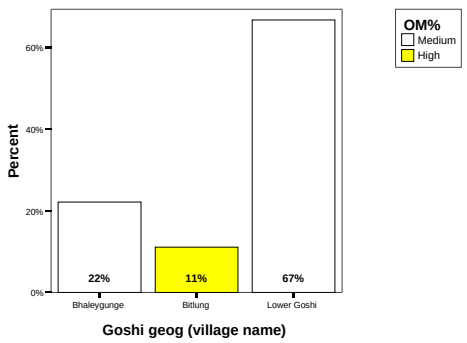

Figure 2b OM% of Goshi geog

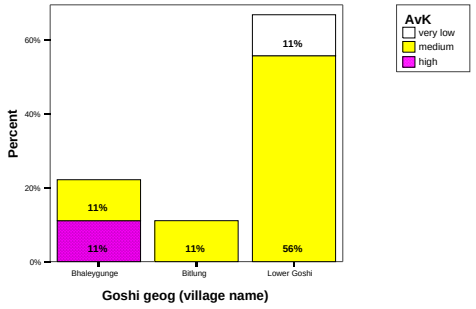

Figure 2c Available K of Goshi geog

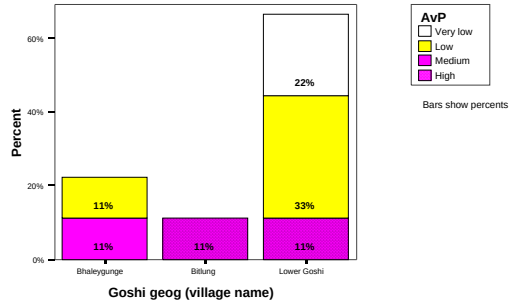

Figure 2d Available P of Goshi geog

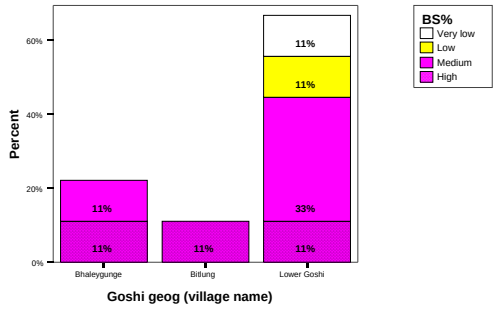

Figure 2e Base saturation (BS%) of Goshi geog .

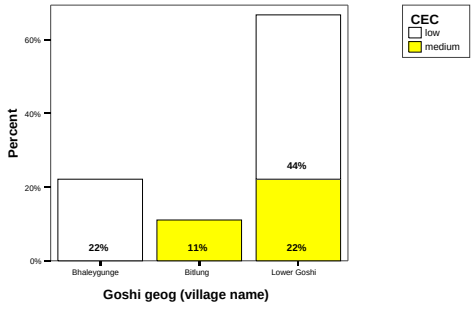

Figure 2f Cation Exchange Capacity (CEC) of Goshi geog

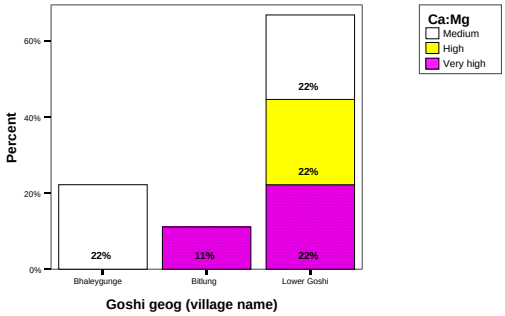

Figure 2g Ca: Mg ratio of Goshi geog .

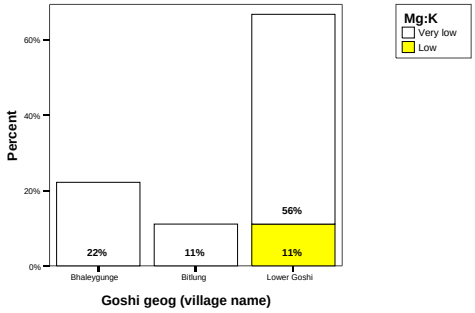

Figure 2h Mg:K ratio of Goshi geog .

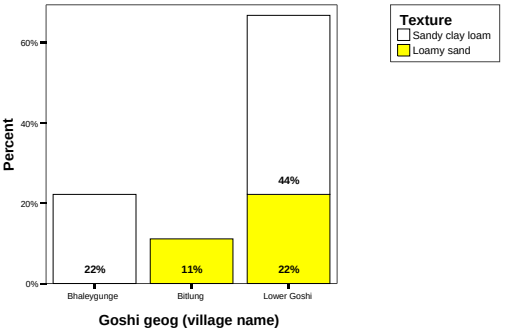

Figure 2i Soil texture of Goshi geog .

3.4.3 Soil results of Tashiding geog

The pH of the soils of this geog is within the medium range with the exception of one farmer *(Chatturman Waiba) with very low pH value (pH of 4.75).* The OM% content of this geog is mostly of medium range with few in the high range. The available K content of this geog is varies from low to medium to high to very range within the majority in the medium range. *Maita Singh Waiba has low available K* while Dil Maya Tamang has very high K. With the exception for *Chatturman Waiba with low P values*, all the other farmers have medium to high P values. These figures from Chatturman Waiba could indicate that either P could have been fixed in such low pH soils and therefore not available and probably liming could help increasing the soil pH and thereby the availability of P. There is also the need to apply K containing fertilizers to improve the nutrient status of these soils with low K values.

The BS% of these soils is mostly within the medium to high range with very few in the very low-to-low range. The CEC of most of these soils is mostly within then low range with few in the medium range. The Ca:Mg ratio of is within the medium to very high range which suggests that there could be probably Mg deficiency for such high ratios (D.B Waiba, Dil Maya Tamang and Chatturman Tamang). The very low to low ratios of Mg:K in all the villages could suggest that Mg deficiency in these soils. Sandy loam, clay loam and silty loam are the common soil types of this geog.

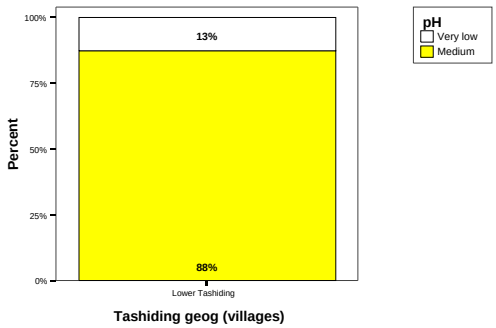

Figure 3a pH values of Tashiding geog .

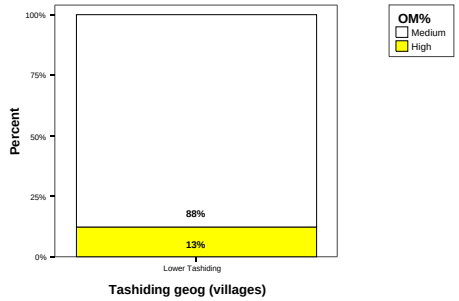

Figure 3b OM% of Tashiding geog

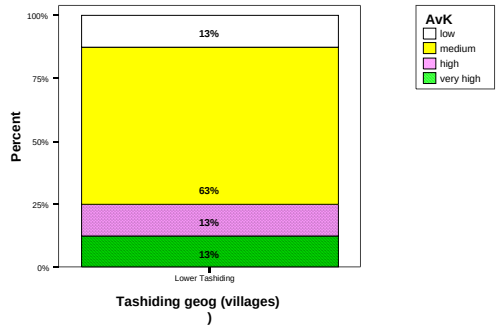

Figure 3c Available K of Tashiding geog

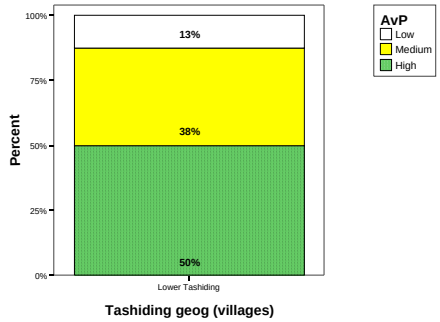

Figure 3d Available P of Tashiding geog

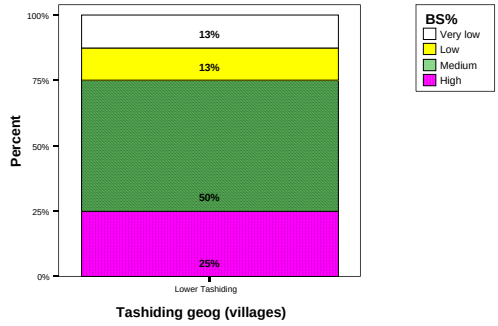

Figure 3e Base Saturation (BS%) of Tashiding geog .

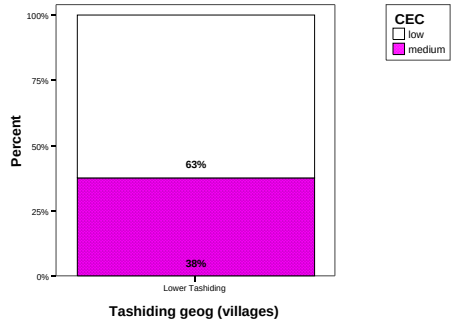

Figure 3f Cation Exchange Capacity (CEC) of Tashiding geog

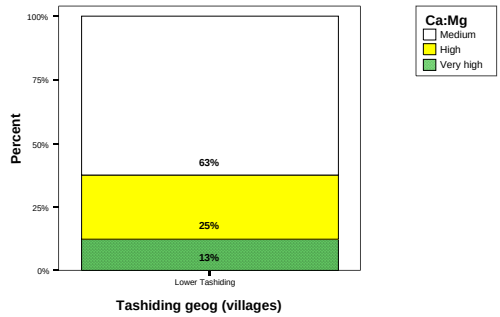

Figure 3g Ca: Mg ratio of Tashiding geog .

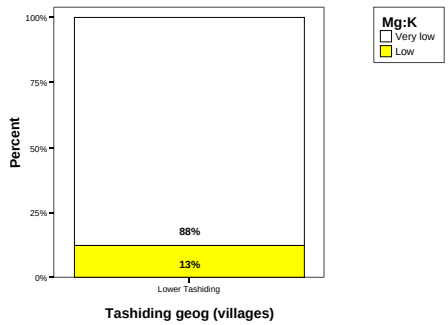

Figure 3h Mg:K ratio of Tashiding geog .

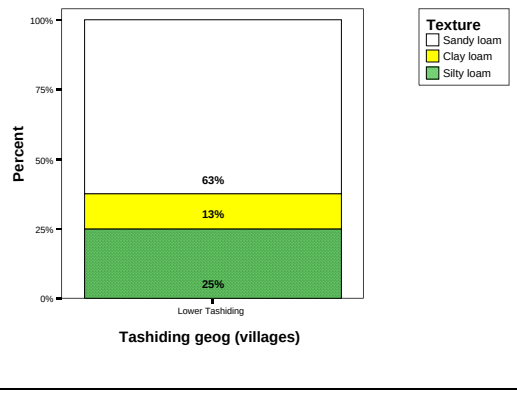

Figure 3i Soil texture of Tashiding geog

3.4.4 Soil results of Tsendgang geog.

The pH of the soils of this geog is mostly within the medium (pH 5.5-6.5) range with the exception of Upper plot of Nar Maya Rai with a slightly higher pH value (pH of 6.57). The OM% content of this geog is within the medium range to high range. The available K content of this geog is mostly in the medium range with one farmer in the very high range (K.B Rai). *The Available P of this geog is mostly low* with the exception of the upper plot of Nar Maya Rai with high P values. These figures suggest that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils with low P values. However, even for those farmers with medium values of K could apply K containing fertilizers since K is needed for fruit development and from the survey, it was found that all the trees were in the bearing stages.

The BS% of this geog is mostly within the medium to high range with the exception of K.B Rai with low values. The CEC of most of these soils is mostly within the medium range with one farmer (Sangay Sherpa) in the low range.

The Ca:Mg ratio of is within the medium to high range which suggests that there could probably be Mg deficiency for those with high ratios (both the plots of Nar Maya Rai). However, the Mg:K ratio of this geog is very low and this could furher suggest a probable Mg deficiency in these soils. The most predominant soil type of this geog is Sandy loam followed by loam and loamy sand.

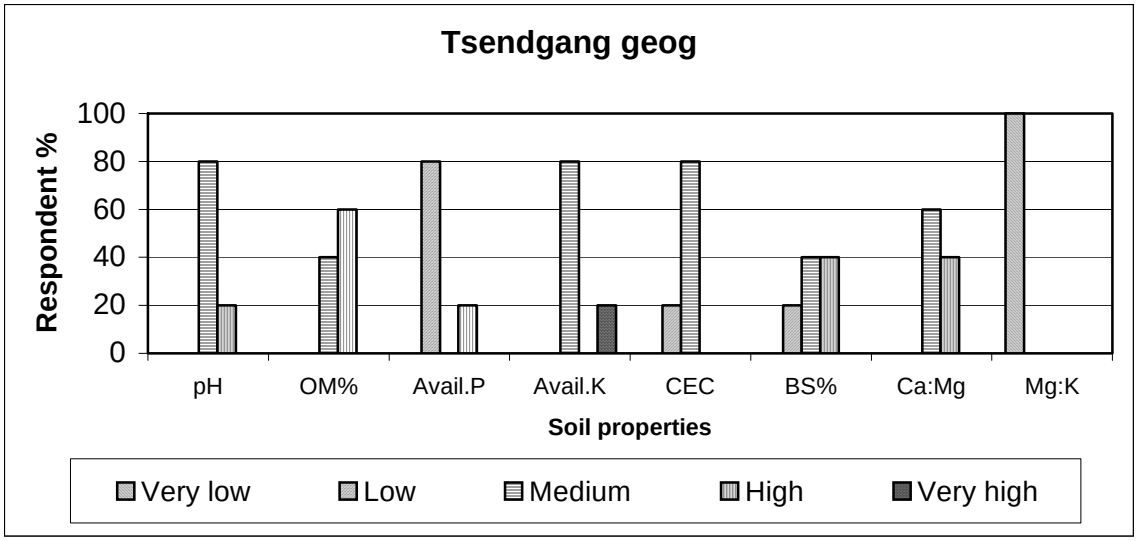

Figure 4 Soil properties of Tsendgang geog

3.4.5 3.4.5 Soil results of Drujaygang geog.

The pH of the soils of this geog is within the medium (pH 5.5-6.5) range. The OM% content of this geog is mostly within the medium range with the exception of Gangchu from Pangna village with low OM% value. *The available K content of this geog is within the medium range.* The Available P of Yangsibi village and Chirigang are in the high range, while that of Thangna village is very low.
These figures suggest that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils with low P values. However, even for those farmers with medium values of K could apply K containing fertilizers since K is needed for fruit development.

The BS% of this geog is mostly within the medium range with the exception of Naku from Thangna with low values. The CEC of most of these soils is mostly within the low range except for Pem Tshewang (Chirigang village) and Rohit Kumar (Pangna) with medium range.

The Ca:Mg ratio of Pangna village and Am Makhum of Thangna, Deki Mo of Yangsibi is of medium range which could indicate no deficiency of either Ca or Mg. Naku of Thangna has low Ca:Mg ratio and could indicate possibly a slight Ca deficiency. This ratio is high for Chirigang (both the plots for Pem Tshewang) and Tshering Zangmo of Yangsibi and this could possibly indicate slight Mg deficiency. However, the Mg:K ratio of this geog is very low and this could further suggest a probable Mg deficiency in these soils.

The main soil type for Chirigang is loam while that of Pangna and yangsibie are sandy loam and sandy clay loam. Loam and clay loam are the two soil types for Thangna.

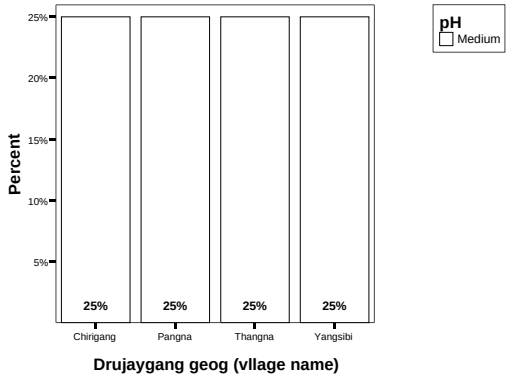

Figure 5a pH values of Drujaygang geog .

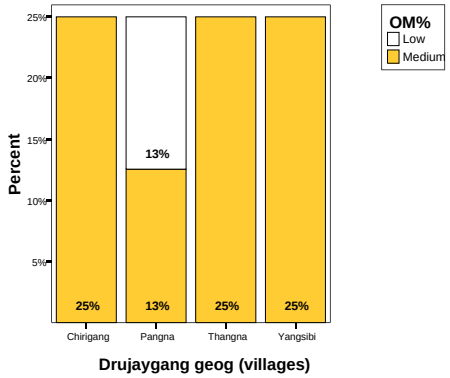

Figure 5b OM% of Drujaygang geog

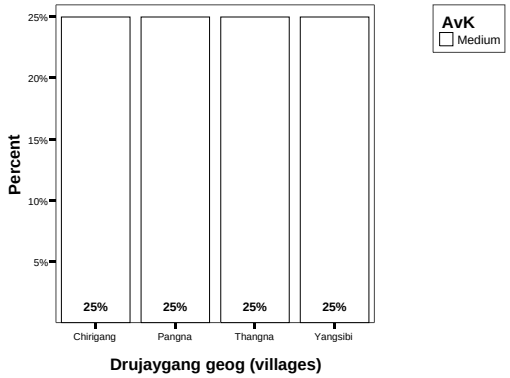

Figure 5c Available K of Drujaygang geog .

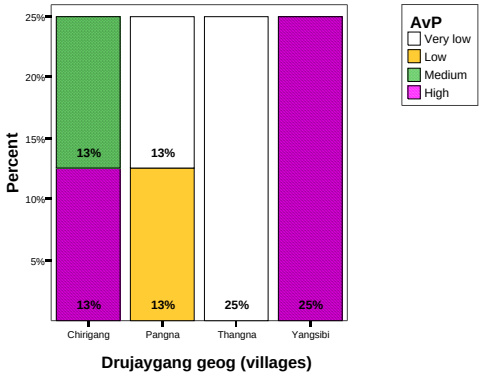

Figure 5d Available P of Drujaygang geog

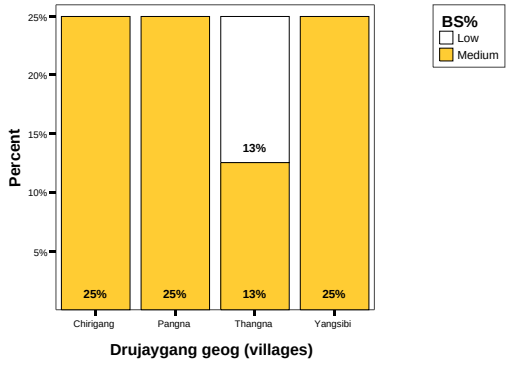

Figure 5e Base Saturation (BS%) of Drujaygang geog .

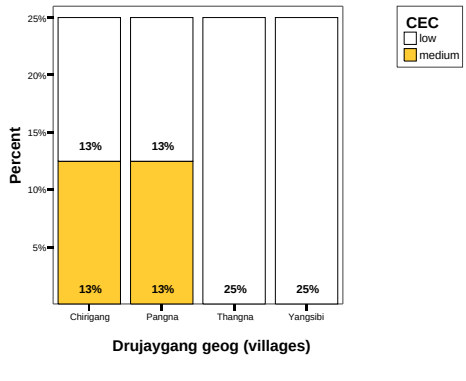

Figure 5f Cation Exchange Capacity (CEC) of Drujaygang geog

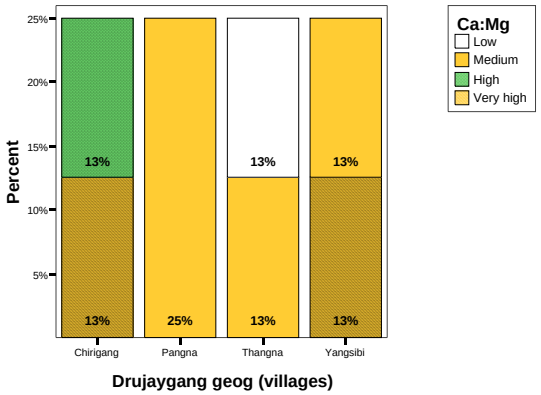

Figure 5g Base Saturation (BS%) of Drujaygang geog .

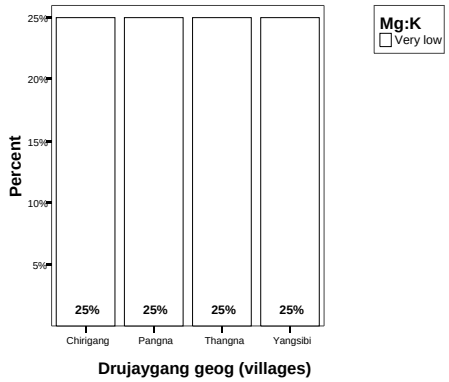

Figure 5h Mg:K ratio of Drujaygang geog

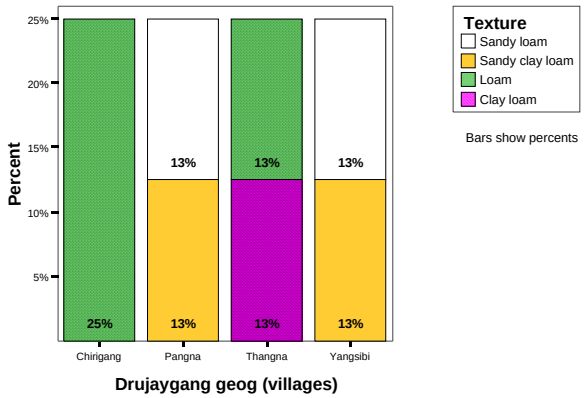

Figure 5i Soil texture of Drujaygang geog

4. Conclusions

Most of the citrus in Dagana Dzongkhag grown at an altitude below 1000 m. asl though it is grown within the range of 550 – 1200 m. asl and located mostly on steep slopes with southeast and southwest aspects.

More than 50% of the farmers apply FYM to citrus at a rate of half a basket to 3 baskets per tree and in addition, more than 80% of the farmers tether cattle in the orchards. The majority of the farmers do not apply any chemical fertilizer to citrus. The small fraction of the farmers that apply chemical fertilizers do so during the winter months from December till April. The two most common types applied are urea and suphala. Majority of the farmers do not irrigate their orchards and is mostly rain fed.

The average soil pH of this Dzongkhag is mostly within the moderate range and that of the organic matter content is also mostly within the medium range. Generally the average available K of this Dzongkhag is within the medium range. The average available P for this Dzongkhag is evenly distributed from very low- to- low- to medium to high values. The average CEC is mostly within the low to medium range while the BS% is also distributed from low to high ranges. Sandy loam and sandy clay loam are the two major soil types of this Dzongkhag.

5. Recommendations

For a precise fertilizer recommendation, yield and management history, sources of plant nutrient applied in the past in particular are required in addition to the soil information. Given the above soil results the following recommendations are suggested to improve the soil nutrient status in this geog.

- The available P content of the soils in most of the villages vary from low to high range and applying P containing fertilizer such as could improve the P content in these soils (especially for those with low values.

- The available K content of these soils is mostly within the medium range. Though K might be adequate for those villages with moderate values, it might not be sufficient for those with low K values and hence the need to apply K containing fertilizer such as MoP to replenish the K content of these soils as K is required especially during fruit development.

- The CEC of most of these soils is within the low to medium range and this low value indicates that almost all the major macronutrients are required to obtain adequate yield.

- An application of balanced nutrients with proper recommended rate needs to be encouraged i.e. the rate of 50:20:100g/tree per year (for non bearing trees) and 150:50:200g/tree/year for bearing trees[4]. From the above mentioned soil information, the following recommendations are suggested to improve the soil nutrient management program: What, when, how and why are answered below.

    1. **Thus the recommended rate of 50:20:100g/tree/year NPK (for non bearing trees)**

    - ***Using SSP, MoP and Urea is as follows:***
        - For 50g N per tree per year, apply 110g/tree/year of Urea as basal dose after harvest and prior to spring flush.

        - For 20g P per tree per year, apply 126g/ tree/year of SSPas basal dose after harvest and prior to spring flush.

[4] For details see table 1.

- For 100g K per tree per year, apply 170g/tree/year of MoP as basal dose after harvest and prior to spring flush.

2. The recommended rate of 150:50:250g/tree/year NPK (for bearing trees)

❖ ***Using SSP, MoP and Urea is as follows:***

- For 150g N per tree per year, apply 330g/tree/year of Urea as basal dose after harvest and prior to spring flush.

- For 50g P per tree per year, apply 315g/ tree/year of SSP as basal dose after harvest and prior to spring flush.

- For 250g K per tree per year, apply 425g/tree/year of MoP as basal dose after harvest and prior to spring flush.

❖ The timing of fertilizer application with adequate soil moisture is crucial for obtaining good yield and therefore, application of fertilizers on dry soil is not encouraged.

Table 1: Suggested fertilizer recommendation rate for citrus trees.

Plant nutrients	Non bearing (g/tree/year)	Bearing (g/tree/year)	Time of application
N	50-100	150-250	After harvest & prior to spring flush
P_2O_5	20-50	50-100	After harvest & prior to spring flush
K_2O	100-150	250-350	After harvest & prior to spring flush
Micronutrients	To be applied based on soil & plant analysis result		When trees have the most fully expanded leaves
FYM	To be applied based upon availability		