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1. Introduction

To build up a database on the soil nutrient status of the major crops in the country to develop a proper fertilizer recommendation rate for crops, soil samples are being collected from the potato maize based farming system in the Eastern Region Dzongkhags, wetland farming system in Punakha-Wangdi valley, and potato based system in Bumthang Dzongkhag. Soil samples will be collected once every two to three years from the same areas. The sampled households are interviewed on their soil fertility management practices, cropping pattern and crop yields.

Trashigang Dzongkhag in the east is the major potato growing Dzongkhags followed by Pema Gatshel and Monggar Dzongkhags. Though potatoes are grown throughout the Dzongkhag, as it is the major source of income for the farmers, the most intensively cultivated areas under Trashigang Dzongkhag are Nanong, Kanglung, Khaling, Yangneer and Thrimshing geogs.

Between 16th November and 15th December 2002, the staff of National Soil Services Centre (NSSC) together with the staff from RNRRC-Khangma, collected soil samples from Nanong geog under Trashigang Dzongkhag.

2. Method

The group collected the soil samples from the farmers' fields based on the list prepared jointly the team together with the farmers and the EA during the one day meeting that was held in the geog. During the meeting, the farmers were explained about the rationale behind collecting soils samples from their fields. Soil samples were collected from the households growing potatoes in two or more langdos (1 langdo= 1350m^2). One composite sample from a minimum of 8-10 sub samples was collected from one field though a composite sample was collected from the clustered fields. Soil samples were collected from the depth of 0-20 cm 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 as recorded during the survey are presented while the soil results for each village under this geog is presented in the second half of this report.

3.1 Nanong geog

3.1.1 Total sample households

In Nanong geog, a total of 108 households covering 10 villages were sampled. The maximum numbers of respondents were from Teyphu, Womchilo and Geeri villages (20% each) followed by Lawteri and Bara gonpa (20% each). Teyphu gonpa (2%), Changchung (3%), Tokaray geeri (4%) and Rashi gonpa (5%) villages had the fewer numbers of respondents. These figures suggest that there were more farmers growing potatoes in Teyphu, Womchilo and Geeri villages compared to Teyphu gonpa, Changchung, Tokaray geeri and Rashi gonpa villages. The various management practices and other site parameters in addition to the soil results are presented below.

3.1.2 Site description:

Altitudes, slopes and aspects of the fields under potato cultivation.

In Nanong geog, about 53% of the sampled plots are located at the low altitude range and the rest at the medium range. The majority of the plots (49%) of this geog are situated on steep slopes and moderately sloping areas (26%) with southwesterly and northeasterly facing aspects (44% and 23% respectively). About 89% of the sampled areas have small plot sizes (<1 acre). The farmers of this geog all grow potatoes mostly in their own fields (98% owned) while only about 2% of the landless farmers share in. About 40% of the farmers still grow their local variety though other varieties such as Desiree, Yusikap and Kufrijyoti are also grown. The majority of the farmers plant their potatoes in December (48%) and January (52%).

3.1.3 Potato and maize yield and other management practices.

The farmers assess their own plot fertility based on the yield, soil type and the slope gradient though different farmers have their own justifications for assessing their plots, which varies from village to village and from household to household. From Figure 1 it can be observed that though the maximum yield (tons/acre) is obtained from level or flat areas (as much as 24t/ac) followed by east and southeast facing aspects.

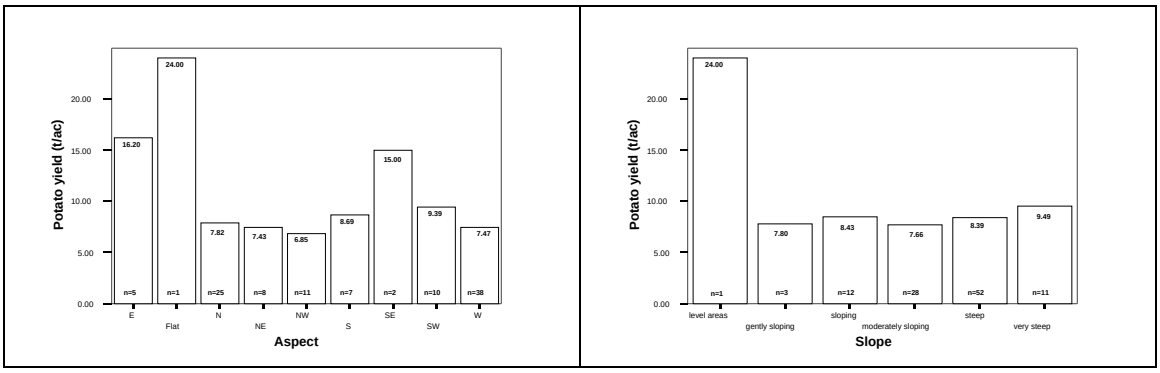

Figure 1 Potato yield in relation to aspect and slope of the plots.

As in any other village or geog in the east, potato is usually intercropped with maize. Maize is mostly sown in March though few farmers sow it in February as well. Under favorable growing seasons, crop management and variety, the potato yield can vary from 16-20t/ac[i] though on an average, the yield is about 7-8 t/ac. The average potato yield for the geog is 8.5t/ac though the highest average potato yield is recorded from Baragonpa village (11.05t/ac) followed by Teyphu gonpa village (11t/ac) and Teyphu (10.65t/ac). Changchung (6.27t/ac), Lawteri (6.3t/ac) and Womchillo (6.4t/ac) villages reported the lowest average yield in this geog. On an average, the maize yield for this geog is 1.4t/ac and the village that reported the highest maize yield is from Baragonpa (4.86t/ac) followed by Rasho gonpa (2.68t/ac). In Nanong geog, Baragonpa village recorded the highest potato and maize yield in comparison to other villages (see figure 2).

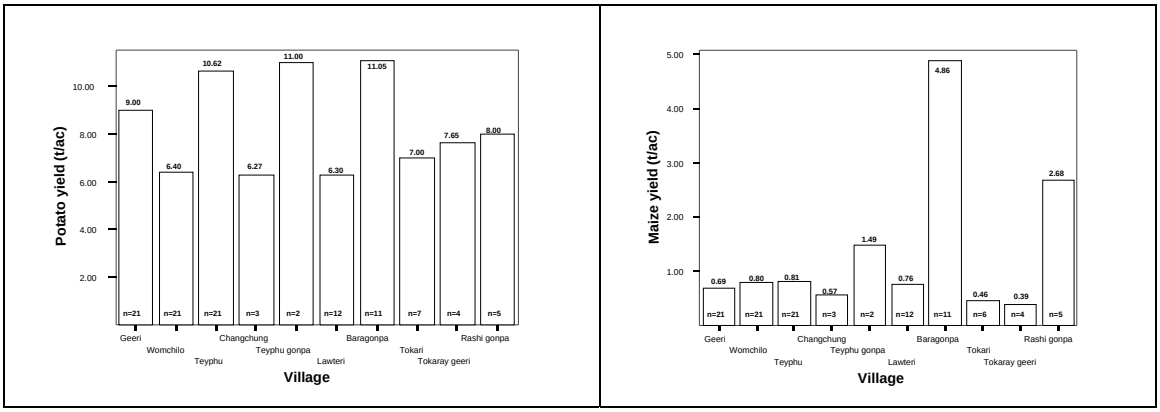

Figure 2 Average potato and maize yield (t/acre) under each village.

In Nanong geog**,** about 99% of the farmers apply Farm Yard Manure (FYM) to their fields with an average application of 18t/ac**.** This amount of FYM applied with a dry matter content of 50% is equivalent to 9t/ac. FYM is usually broadcasted in the fields and incorporated into the soil by ploughing during land preparation. On an average, Lawteri village applied the highest rate of FYM application (42.5t/ac) followed by Tokari geeri (32.6t/ac.) and Baragonpa (26.5t/ac) while Changchung applied the least (4.3t/ac) and the other two villages

[i] *According to FAO reports.*

that applied lesser amount of FYM are Teyphu gonpa (9.4t/ac) and Geeri (9.5t/ac) villages (figure 3). The majority (99%) of the farmers of this geog do not practice tethering of cattle in the fields while 93% of them burn trash after crop harvest prior to land preparation. In this geog, weeding frequency in potato ranges from once to thrice though about 38% of them weed only once while another 33% of the farmers weed thrice and few farmers (5%) weed even as much as more than three times and the rest (about24%) weed twice. Therefore, in this geog, weeding is done intensively.

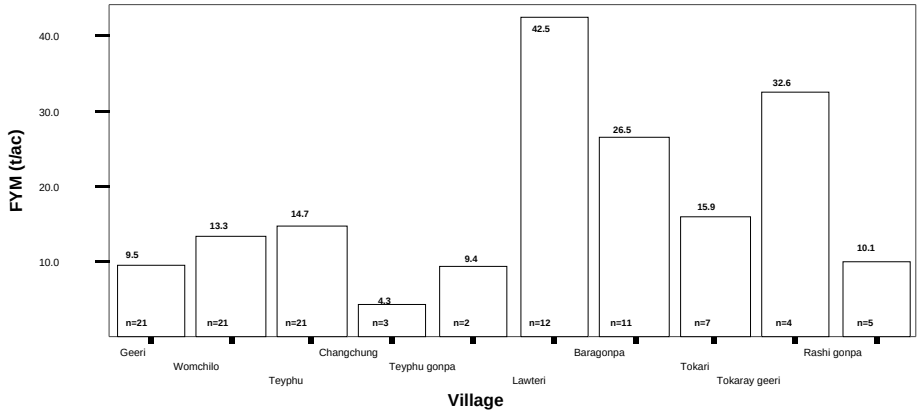

Figure 3 Amount of FYM applied (t/acre) under each village.

The survey findings indicate that about 94% of the farmers apply inorganic fertilizers such as urea and suphala in addition to FYM while SSP is not applied at all. In this geog, about 94% of the farmers apply Supahala to potato (basal dose) while only about 22% of them apply urea basal in potato and only about 6% of them apply urea to maize as top dress. On an average, the farmers of this geog apply about 110kg/ac suphala, which is 17kg N per acre, 17kg P per acre and 17kg K per acre. The average amount of suphala applied by the farmers of Baragonpa village (170.5ka/ac) is more than the rest of the other villages while Womchillo village applied the least (67kg/ac), Figure 4.

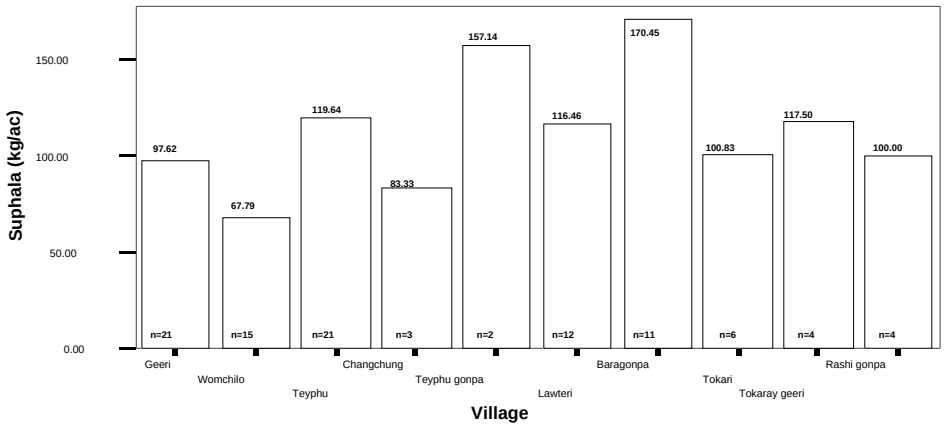

Figure 4 Amount of Suphala (kg/acre) applied under each village.

The average application of urea in potato for this geog is 61kg/ac (which is 29kg N per acre) as basal dose, which is applied by only 4 villages in this geog (viz. Rashi gonpa, Geeri, Womchilo and Teyphu). From these 4 villages, on an average the highest amount of urea application to potato is from Rashi gonpa village (36.7kg/ac) followed by Geeri (29.2kg/ac) while villages like Changchung, Lawteri, Teyphu gonpa, Baragonpa, Tokari and Tokari geeri do not apply urea in maize.

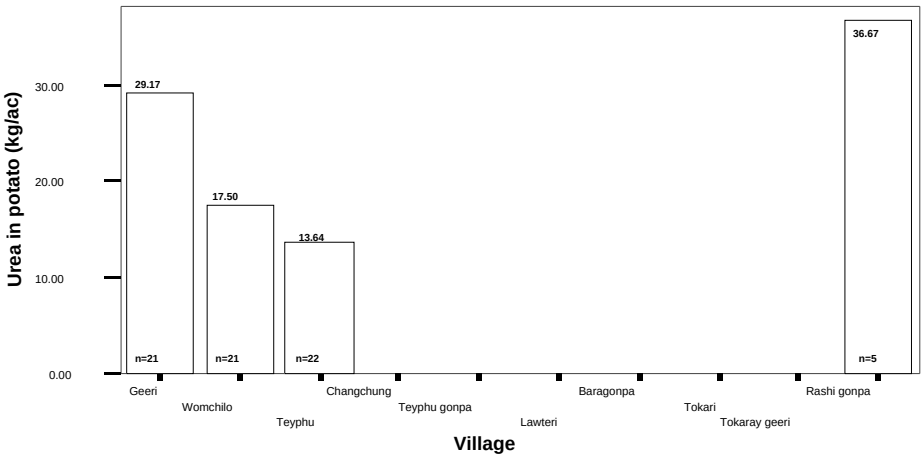

Figure 5 Amount of Urea (kg/acre) applied to potato under each village.

The farmers of this geog dot not at all apply SSP while about only 6% of the farmers (i.e. only 3 villages, viz. Geeri, Teyphu and Teyphu gonpa) apply on an average 47kg/acre of urea (i.e. about 22kg N per acre) as top dress to maize. Of these 3 villages, on an average, the highest amount of urea application as top dress in maize is reported from Teyphu gonpa (61kg/ac) (while the other villages applied less than 5kg/ac, see figure 6. The basal fertilizer is applied in a band while urea top dress, broadcasted near the plants is mostly applied in a single dose

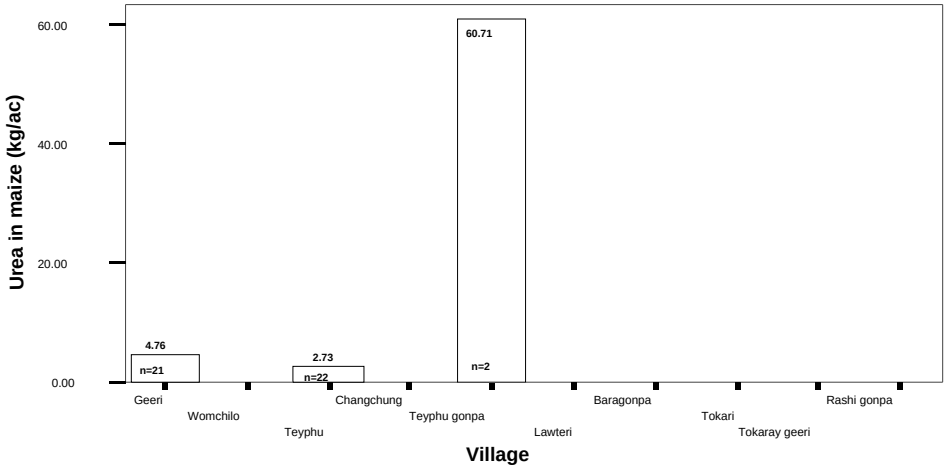

Figure 6 Amount of Urea (kg/acre) applied in maize under each village.

3.1.4 Soil results of Nanong geog.

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.

Potato can be grown in most soil types where though its greatest productivity is from a deep, loose, crumbly and well-aerated soil. It does well in slightly acidic soils (pH range of 5.0-5.8) while it is not suitable if the soil pH is either <4.5 or is >7.0. Alkaline soil conditions can adversely affect skin quality and high alkaline soils can also induce micronutrient deficiencies. The soil results of each village under Nanong geog is summarised as follows.

i. Soil result of Geeri village (see figure 7).

The pH of the soils of this village is of medium (pH 5.5-6.5) to high range (6.5-7.5). As any other crops, potatoes also require adequate amount of N, P and K for optimum crop yield although its N and K requirements are high. Potatoes are efficient removers of K. About 67% of these soils have low available K (40-99mg/kg) of which about 19% is in the very low range (<40mg/kg). About 60% of these soils have low P (5-15mg/kg) values of which 19% is in the very low (<5mg/kg) range. These figures suggest that there is a need to apply P and K containing fertilizers such as **SSP and MoP** to improve the nutrient status of these soils. The organic matter of these soils is high with high C:N ratio. The

CEC of these soils is of medium (15-25me/100g) to high (25-40me/100g) range while the BS% is high (BS>80%). Coarse-textured soils lack both nutrient and water holding capacities while fine-textured soils often have structural and infiltration problems. The major soil type is silty clay loam, a medium textured soil containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

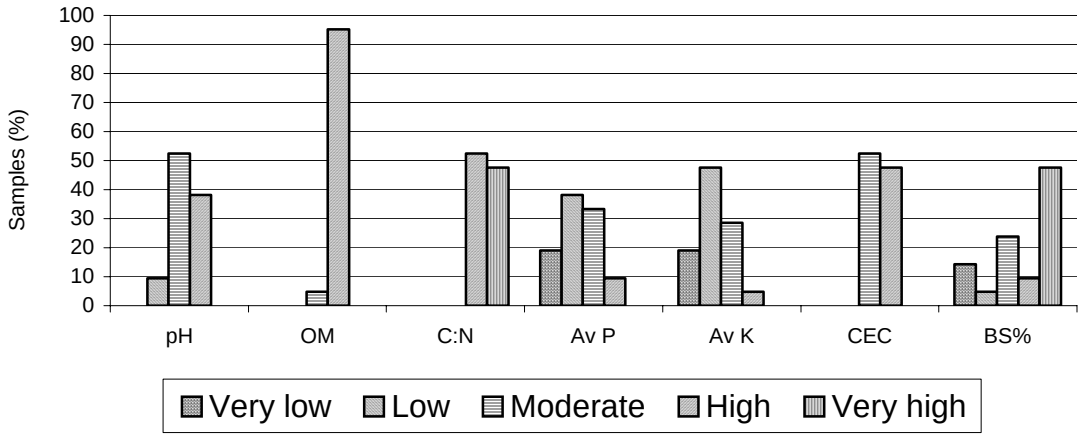

Figure 7 Soil parameters of potato fields in Geeri village.

ii. Soil result of Womchilo village (see figure 8).

The pH of the soils of this village is of medium to high range. The available K is within the low to medium range with more than 75% in the low range. The available P of these soils is within the very low to moderate range with more than 40% in the low range. This low figure of available P and K suggests that there is the need to apply P and K containing fertilizers such as **SSP and MoP.** The organic matter content of this village is high with very high C:N ratio. The CEC values are within the medium range and the BS% is distributed within low to high ranges. The major soil type found in this village is silty clay loam (medium textured soil containing less then 40% clay) and silty clay (clay content of 40-60%).

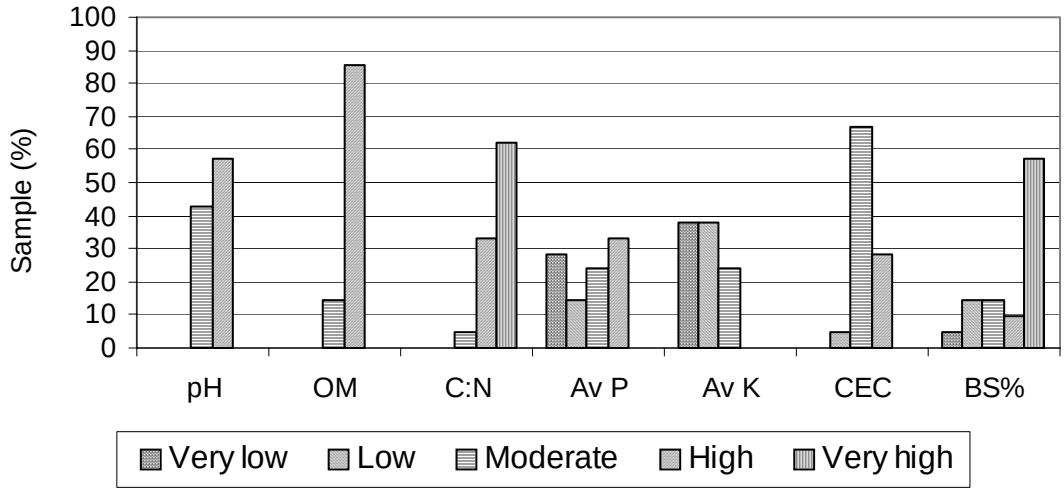

Figure 8 Soil parameters of potato fields in Womchilo village.

iii. Soil result of Teyphu village (see figure 9).

The pH of the soils of this village is mostly within medium to high range. About 95% of these soils have low available K with almost 53% in the very low range and about 45% in the low range. The available P of these soils is also in the low range (i.e. with 77% in the low range and 59% in the very low range). These low P and K figures suggest the need to apply P and K containing fertilizers such as **SSP and MoP** respectively to improve the nutrient status of these soils. The organic matter contents of these soils is within the medium to high range with high C:N ratio. Silty clay loam and silty loam are the major soil types of this village.

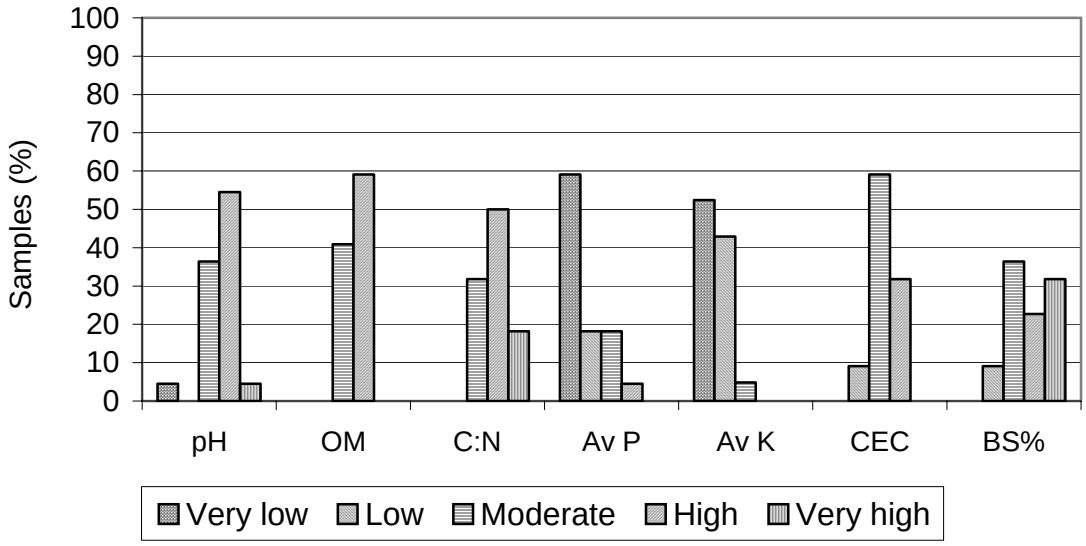

Figure 9 Soil parameters of potato fields in Teyphu village.

iv. Soil result of Teyphu gonpa village (see figure 10).

The pH of the soils of this village is high range. All the soils of this village have very low available K. The available P of these soils is also in the low range (i.e. with 50% in the low range and 50% in the very low range). These low P and K figures suggest the need to apply P and K containing fertilizers such as **SSP and MoP** respectively to improve the nutrient status of these soils. The organic matter contents of these soils is within the medium range with medium C:N ratio. Silty loam is the major soil type of this village.

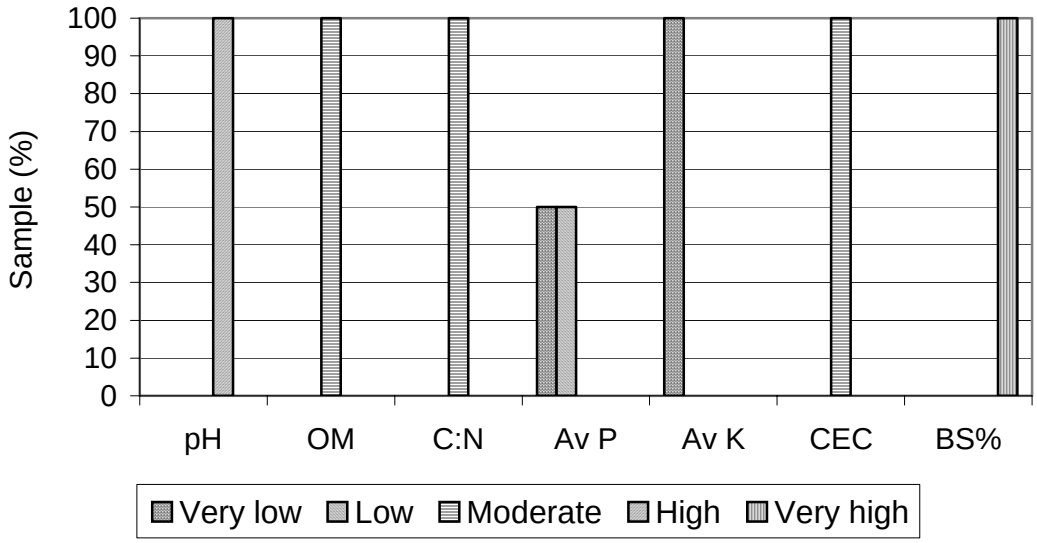

Figure 10 Soil parameters of potato fields in Teyphu gonpa village.

v. Soil result of Changchung village (see figure 11).

The pH of the soils of this village is mostly within the medium to high range. All the soils (100%) of this village have **low available K** while the available P of these soils is equally distributed (33% each) between low, medium and high range. These low K and P figures suggest that there is the need to apply P and K containing fertilizers such as **SSP and MoP** to improve the nutrient status of these soils. The organic matter content of these soils is within the moderate to high range while the C:N ratio is within high to very high range. The CEC of these soils is very low with medium BS% range. In such low CEC soils, all major macro and micronutrients are required to attain adequate growth and thereby yield. The major soil type of this village is silt loam.

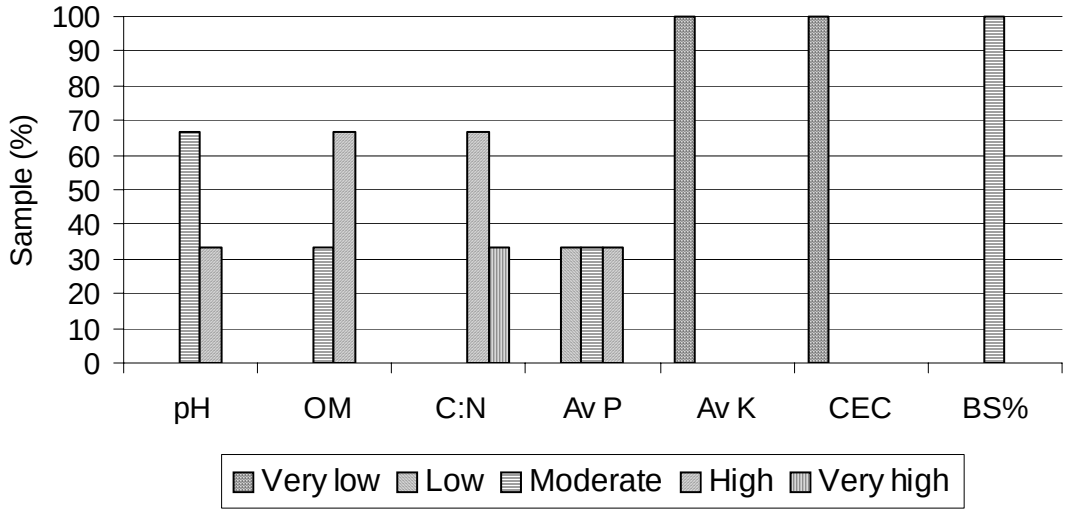

Figure 11 Soil parameters of potato fields in Changchung village.

vi. Soil result of Lawteri villages (figure 12).

The pH of the soils of this village is of medium range. The available K is in the low to medium range with more than 33% in the low range and the available P of these soils is low with 92% in the low range. These low K and P figures suggest that there is the need to apply P and K containing fertilizers such as **SSP and MoP** to improve the nutrient status of these soils. The organic matter content of these soils is high range with high to very high C:N ratio. The CEC values of these soils are of medium range to high range while the BS% range of these soils is equally distributed from very low to high ranges. The major soil types of this village are silty clay loam while clay soil is also found in few plots.

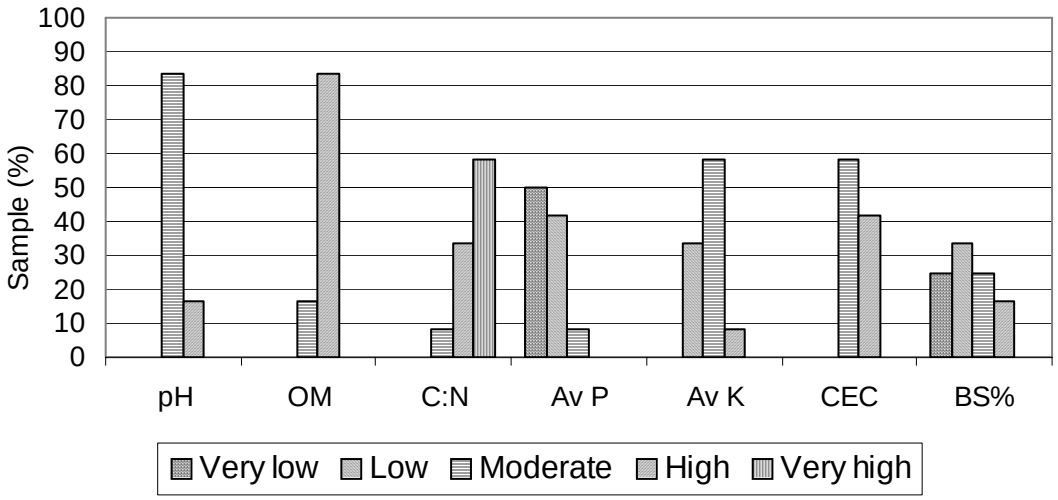

Figure 12 Soil parameters of potato fields in Lawteri village.

vii. Soil result of Baragonpa village (see figure 13).

The pH of the soils of this village is mostly within the low to medium range. All the soils of this village have low available K and P with about 30% of the plots have very low K and another 82% have very low P. This low P and K figures suggest the need to apply P and K containing fertilizers such as **SSP and MoP** to improve the P and K status of these soils. The organic matter content of these soils is of medium range with very high C:N ratio. The CEC of these soils is high with very low BS%. Silty clay loam is the major soil type of this village.

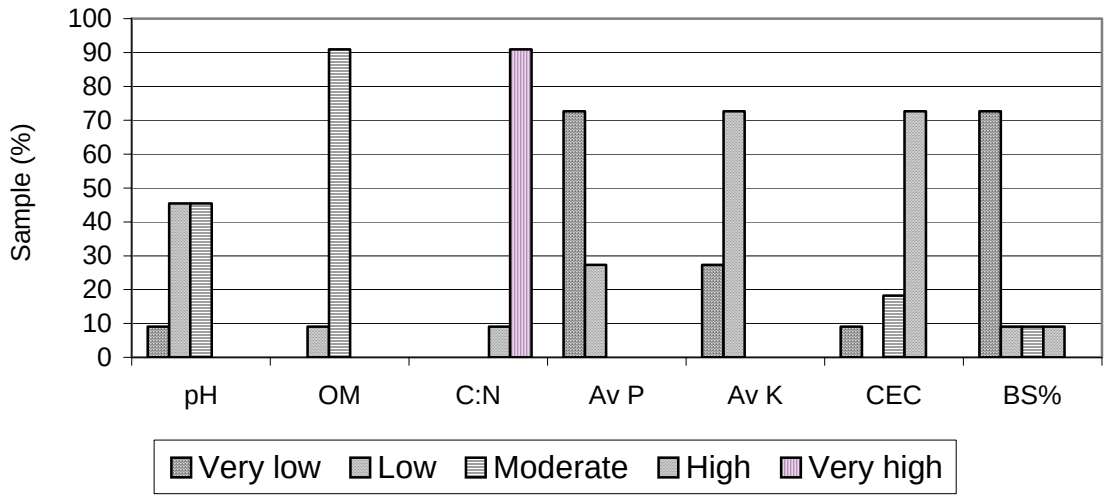

Figure 13 Soil parameters of potato fields in Baragonpa village.

viii. Soil result of Tokari village (see figure 14).

The pH of the soils of this village is of medium range. The available K is in the low to medium range with 43% in the low range. The available P is all in the low range with 57% in the very low range. These low P and K figures suggest the need to apply P and K containing fertilizer such as **SSP and MoP** to improve the P and K status of these soils. The organic matter content of these soils is high with high to very high C:N ratio. The CEC of these soils is very high while the BS% range of these soils is distributed from very low range to medium range. Silty clay loam and silt are the major soil types of this village.

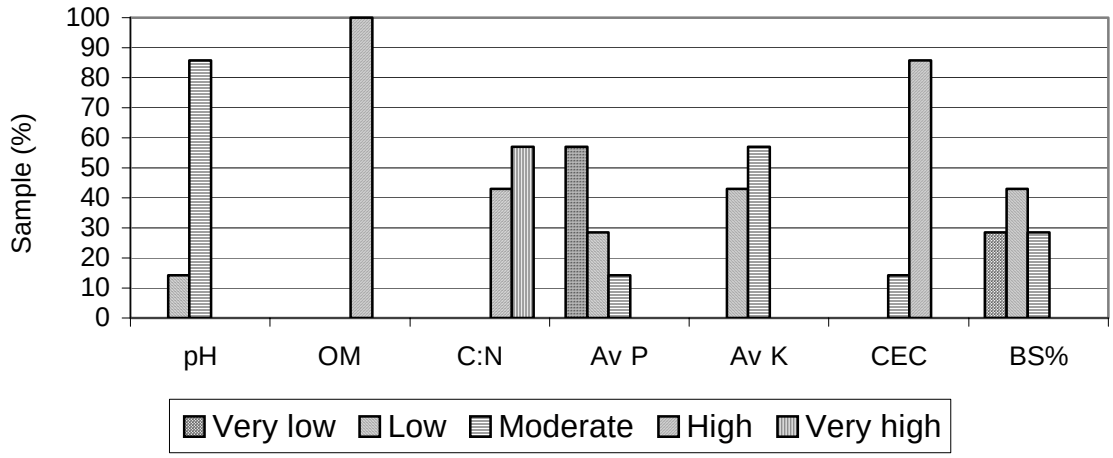

Figure 14 Soil parameters of potato fields in Tokari village.

ix. Soil result of Tokari geeri village (see figure 15).

The pH of the soils of this village is within the low to medium range. The available K ranges from low to medium range (50% each). The available P is also within low to medium range with 25% in the low range and the rest in the medium range

therefore the need to apply P and K containing fertilizers such as **SSP and MoP** to improve the K status of these soils. The organic matter content of these soils is high. The CEC of these soils is in the medium range while the BS% varies from low to high ranges. Silty loam is the major soil type of this village.

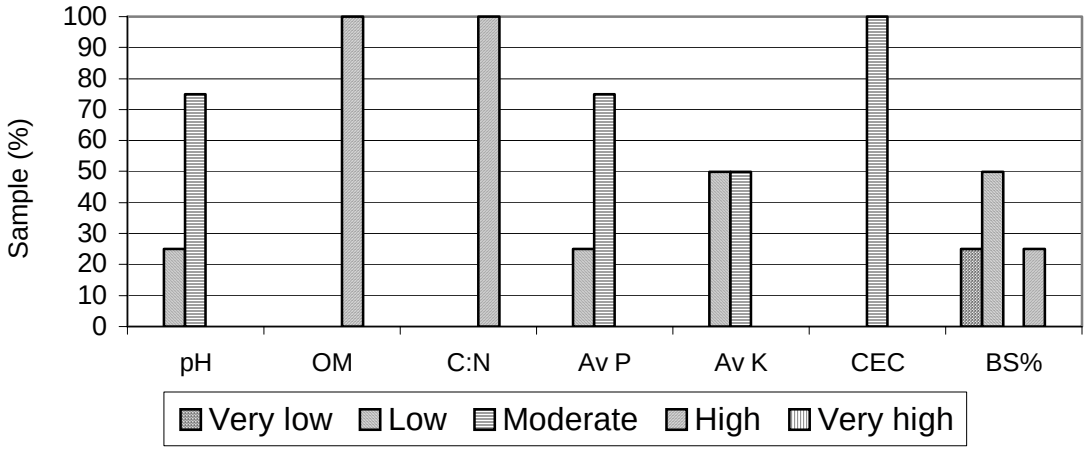

Figure 15 Soil parameters of potato fields in Tokari geeri village.

x. Soil result of Tokari gonpa village (see figure 16).

The pH of the soils of this village is of medium range. The available K of this village (100%) is low with 20% in the very low range**.** About 60% of these soils have low available P content with 40% in the very low range**.** Therefore there is the need to apply P and K containing fertilizers such as **SSP and MoP** to improve the K content of these soils. The organic matter content of these soils is of low to medium range with high C:N ratio. The CEC of these soils is of medium range while the BS% range of these soils is evenly distributed from very low to high range. Silty loam is the prominent soil type found in this village.

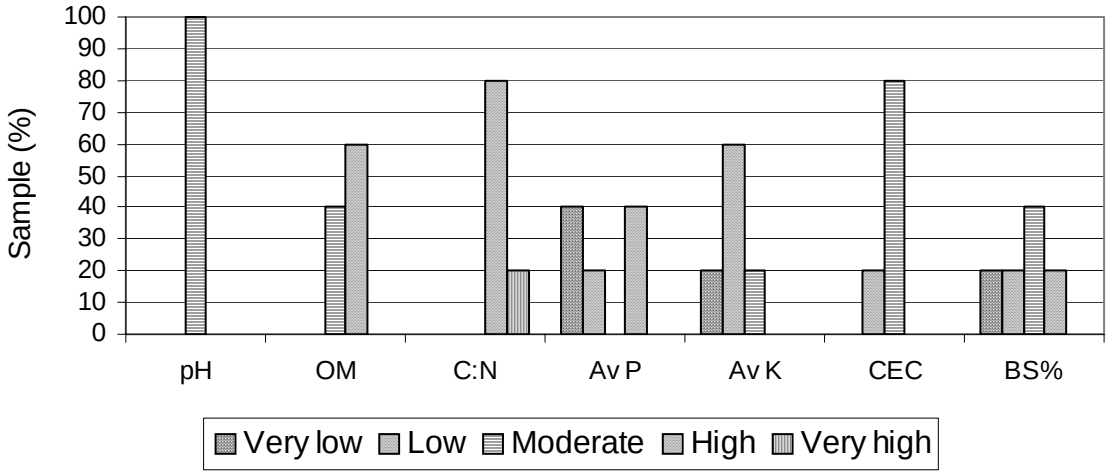

Figure 16 Soil parameters of potato fields in Tokari gonpa village.

4. Conclusions

In Nanong geog the potato fields are mostly located at the low to medium altitude range with the majority of the plots situated on steep slopes and moderately sloping areas with south-westerly and north-easterly facing aspects. Almost all the sampled areas have small plot sizes (<1 acre). The majority of the farmers still grow their local variety though other varieties such as Desiree, Yusikap and Kufrijyoti are also grown and potatoes are planted in December and January. Potato is intercropped with maize, which is sown within one to two months after planting potato. The average potato and maize yield for the geog is 8.5t/ac and is 1.4t/ac respectively. Almost all the farmers apply Farm Yard Manure (FYM) to their fields with an average application of 18t/ac. In addition, few farmers apply inorganic fertilizers like urea and suphala to potato and maize. Urea in maize is all applied as a single top dress**.** Tethering of cattle is not a common practice while all the farmers burn the crop residues prior to land preparation. Weeding frequency ranges from once to thrice.

In general, the soil pH of this village is mostly within the moderate range while the available P on an average is low and the K content on an average is also low. Therefore, the need to improve the soil nutrient status and hence the yield by applying P and K containing fertilizers for those villages with low values. In general, the organic matter content is high while the CEC and BS% are within the medium range. The major soil type found in this village is silty clay loam.

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 (Section 3.2.3) the following recommendations are suggested to improve the soil nutrient status in this geog.

- Both the available P and K content of the soils are low in this village and in addition, potatoes are efficient removers of K. Applying appropriate fertilizers such as SSP and MoP together with urea as a basal dose could improve the P and K contents in these soils.

- An application of balanced nutrients with proper recommended rate needs to be encouraged. For this geog one set of recommendation is enough as all the villages in this geog have both P and K contents low. Based on the above mentioned soil information, the following recommendation is suggested to improve the soil nutrient management program: What, when, how and why are answered below.

A. Thus the recommended rate is 100:100:100 kg/ha of N,P,K.

1. Using Suphala is as follows:
    - Apply about 270 kg/acre of Suphala as basal dose during land preparation (i.e. about $5^1/_2$ bags of Suphala @50 kg per bag per acre) as one straight dose or

- Apply about 216kg/acre of suphala as basal dose during land preparation (i.e. about $4^{1}/_{3}$ bags of suphala @50kg per bag per acre) together with 50kg of SSP (i.e. 1 bag of SSP @50kg per bag per acre) and about 14 kg of MoP as basal dose; followed by about 17 kg of urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (i.e. when the maize plants are of "knee high" stage).

2. Using SSP, MoP and Urea [ii] is as follows:

- Apply 69kg/acre of Urea as basal dose during land preparation (i.e. about 1 bags of Urea @50 kg per bag per acre).

- Apply about 253kg/acre of SSP as basal dose during land preparation (i.e. 5 bags of SSP @ 50 kg per bag per acre).

- Apply about 67kg/acre of MoP as basal dose during land preparation (i.e. about 1 bag of MoP @ 50 kg per bag per acre).

- Followed by 17 kg urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (or when the maize plants are of "knee high" stage).

[ii] If the farmers are willing, this second type of application is more advisable than the first type as the SSP contains additional nutrient (sulphur), which helps in better production of yield.