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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.

Monggar Dzongkhag in the east is one of the major potato growing Dzongkhags next to Trashigang and Pema Gatshel Dzongkhags. Though potatoes are grown throughout the Dzongkhag, the most intensively cultivated area is under Drametse geog.

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 Drametse geog under Monggar 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 growing potatoes in two or more langdos (1 langdo= 1350m²). 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 Drametse geog

3.1.1 Total sample households

In Drametse geog, a total of 98 households covering 14 villages were sampled. The highest number of respondents was from Yangertse village (15%) followed by Khalong (13%), Bazor (12%) and Zangkhar (11%) villages. Khueysingmu and Lemi villages had the lowest number of respondents. These figures suggested that there were more farmers growing potatoes in Yangertse, Khalong, Bazor and Zangkhar villages compared to Khueysingmu and Lemi 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.

For potato to do well, an ideal situation is have the fields with slopes less than 10% with either east or west facing aspects. However, it can also do moderately well on slopes ranging from 10-30% and with aspects facing either NNE-E or W to NNW. In Drametse geog, almost 50% of the sampled plots are located at the low altitude range (less than 2000 m.asl) and the rest at the medium range (between 2000 and 3000 m.asl). The majority of the plots (72%) of this geog are situated on steep slopes (>25%) and few plots about 5% are located on very steep slopes (>50%). The majority of the plots are north-easterly facing aspects and 83% of the sampled area have small plot sizes (<1 acre). The farmers of this geog all grow potatoes in their own fields (100% owned) unlike in other geogs where the plots are either shared in or shared out. All the farmers grow the red variety (i.e. Desiree). About 73% of the farmers start planting potatoes in February though few farmers plant as early as January and as late as March.

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 sloping and east facing areas, the majority of the plots are located in the steep areas with east facing aspects.

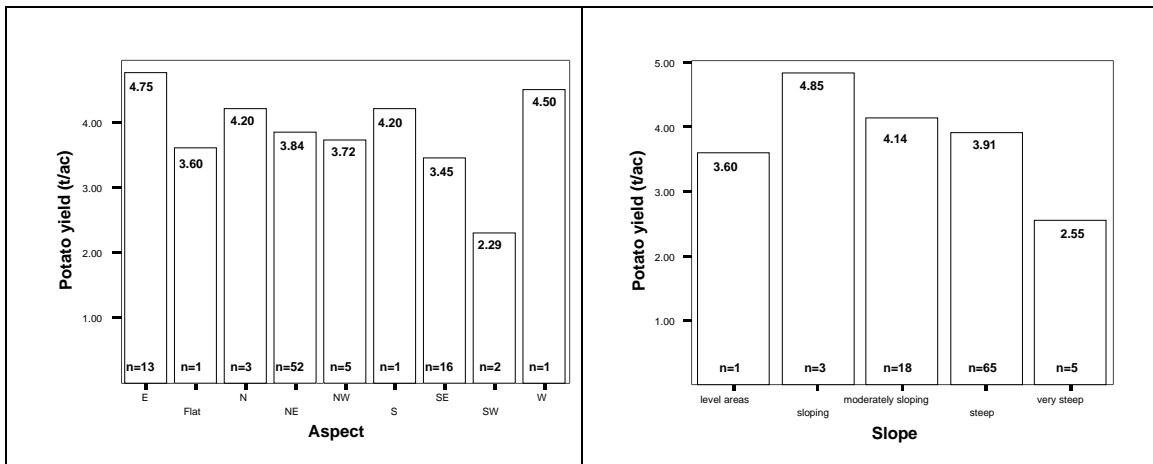


Figure 1 Potato yield in relation to aspect and slope of the plots.

As in any other village or geog in the east, potato is usually intercropped with maize. Maize is usually sown about a month after potato. Under favorable growing seasons, crop management and variety, the potato yield can vary from 16-20t/ac¹ though on an average, the yield is about 7-8 t/ac. The highest average potato yield is recorded from Shafangma (6.08t/ac) and Drametse (5.87t/ac) villages Lebri (2.55t/ac) and Khesung (2.71t/ac) villages reported the least yield though the average potato yield for Drametse geog is 3.9t/ac. The highest maize yield is recorded form Shafangma (5.41t/ac) and Bazor (5.14t/ac) villages while the lowest yield is reported from Khueysingmu (0.75t/ac) and Lebri (1.65t/ac) (see figure 2). On an average, the maize yield for this geog is 3.6t/ac and the farmers of this geog reported that the maize production is quite adequate for their daily consumption.

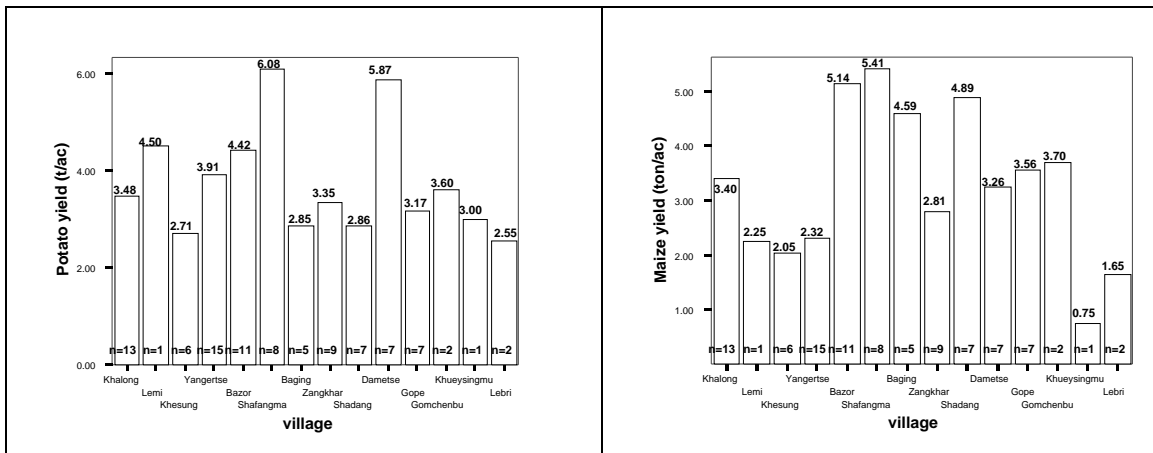


Figure 2 Average potato and maize yield (t/acre) under each village.

In Drametse geog, about 99% of the farmers apply Farm Yard Manure (FYM) to their fields with an average application of 16.6t/ac. This amount of FYM applied with a dry matter content of 50% is equivalent to 8.3t/ac (which is equivalent to 115kg N/ac, 25kg P/ac and 165kg K/ac). FYM is usually broadcasted in the fields

Which is incorporated into the soil by ploughing during land preparation. The highest rate of FYM application (t/ac) is one farmer from Khueysingmu village (45t/ac) followed by Baging (41.85t/ac) villages while Gomchenbu (7.65t/ac) village applied the least amount of FYM (figure 3). Tethering of cattle in the fields is not practiced in this geog though trash burning is done by almost all the farmers (97% of the households). The weeding frequency of the potato ranges from once to thrice though majority (70%) of the farmers do weeding twice.

The survey findings indicate that about 90% of the farmers do not apply any of the inorganic fertilizers such as urea, sulphala and SSP but is all subsisted by FYM application. Therefore, there is a potential for increasing the productivity with proper and balanced use of fertilizers since the present management practices indicate that the only source of nutrients for growing crops is the traditional FYM. However, about 6 farmers in this geog apply urea to potato with a rate of 65 kg per acre (which is about 31 kg N per acre). The farmers who applied urea to maize used on average about 84 kg/acre, which is about 40kg of N per acre. The amount of N applied from urea is more or less equal to the recommended rate of 36:32:12 kg/acreⁱⁱ of N, P K or 100:80:60 kg/ha (i.e. 40:32:24 kg/acre of NPK from SSF&PNMⁱⁱⁱ) of N, P and K respectively though the other two major nutrients are not at all replenished. About only 3 farmers apply sulphala to potato at the rate of 142kg per acre, which is equivalent to 21kg each of N, P and K per acre.

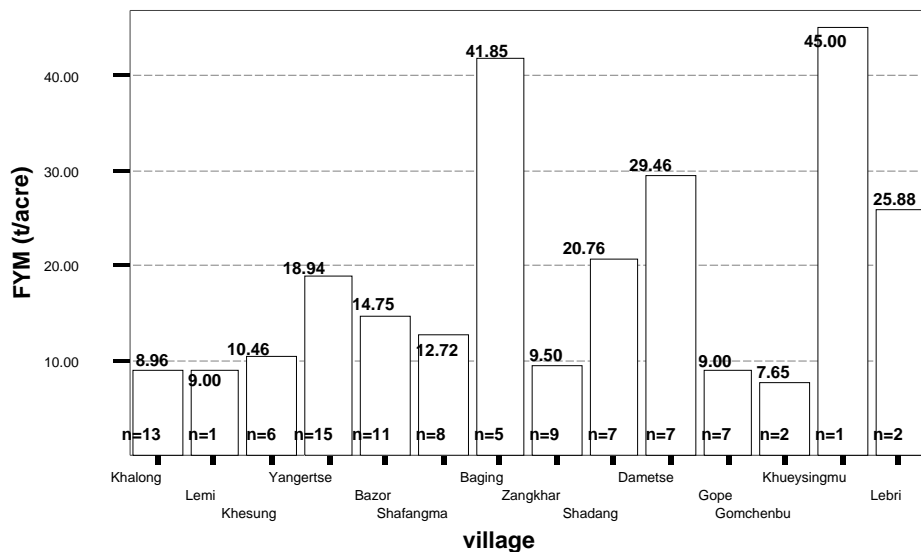


Figure 3 Amount of FYM applied (t/acre) under each village.

3.1.4 Soil results of Drametse geog.

In the soil analysis result, with the exception of soil pH, the classifications are 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. An ideal CEC and BS% range for potatoes are the ranges which is CEC >15 meq/100g and BS% >60 respectively. The soil results of each village under Drametse geog are summarized as follows.

i. Soil result of Khalong village (see figure 4)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) to high (pH 6.5-7.5) range. As in 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.

The available K is in the medium (100-199mg/kg) to high (200-299mg/kg) range. More than 30% of these soils have low available P (5-15mg/kg). This figure suggests that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils though the K levels are fairly adequate. More than 90% of these soils have high organic matter contents (> 5%) and almost 70% these soils have very high C:N ratio (>12).

The CEC of these soils is mostly within the medium (15-25 meq/100g) to high range (25 - 40meq/100g). The BS% range of these soils is evenly distributed from very low to very high range with more than 50% in the high range (65-79%). 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 and clay loam (figure18). This soil type is of medium textured soils containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

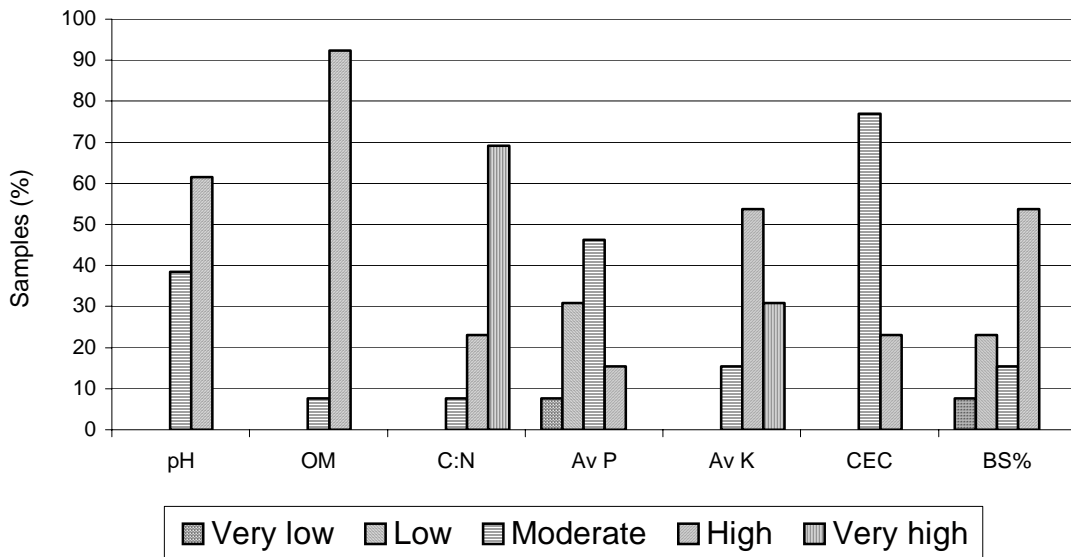


Figure 4 Soil parameters of potato fields in Khalong village.

ii. Soil result of Lemi village (see figure 5)

The pH (pH 6.5-7.5) and the OM content (>5%) of the soils of this village high. 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. The available K is in the medium (100-199mg/kg) and the available P (15-29mg/kg) and CEC are also in the medium range (15-25 meq/100g). This figure suggests that there is a need to apply K containing fertilizers such as MoP to improve the nutrient status of these soils as potatoes remove sufficient amount of K from the soils though the P level is fairly adequate. The BS% of this soil is very 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 clay loam (figure18). This soil type is of medium textured soils containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

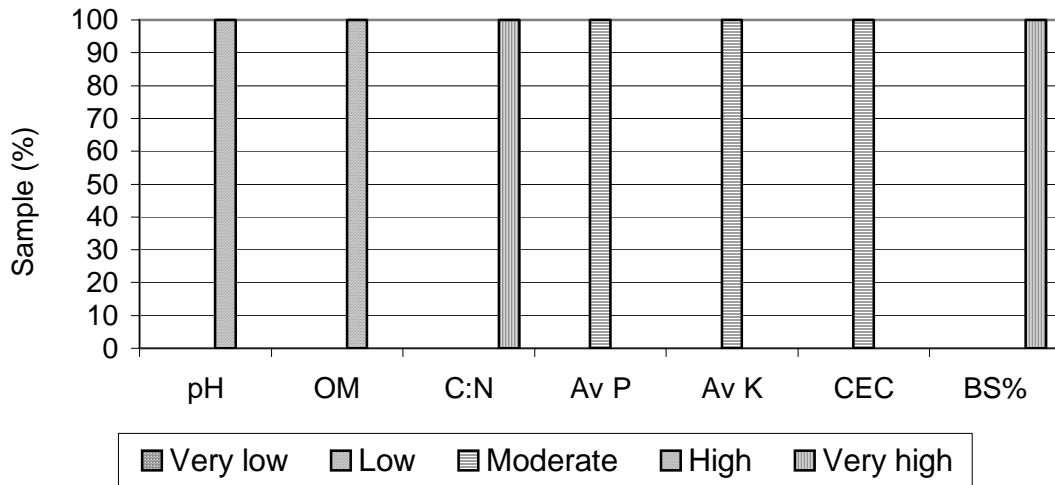


Figure 5 Soil parameters of potato fields in Lemi village.

iii. Soil result of Gomchenbu village (see figure 6)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) to high (pH 6.5-7.5) range. The available K is in the medium (100-199mg/kg) to high (200-299mg/kg) range). About 50% of these soils have low available P (5-15mg/kg) and another 50% of these soils have high available P (15-30 mg/kg). This figure suggests that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils though the K levels are fairly adequate. The soil organic matter content is high (> 5%) and almost 50% each of these soils have very high C:N ratio (>12) and high ratios.

The CEC of these soils is all within the medium (15-25 meq/100g) range while the BS% range of these soils is evenly distributed between medium and very high. 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 clay loam (figure18). This soil type is of medium textured soils containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

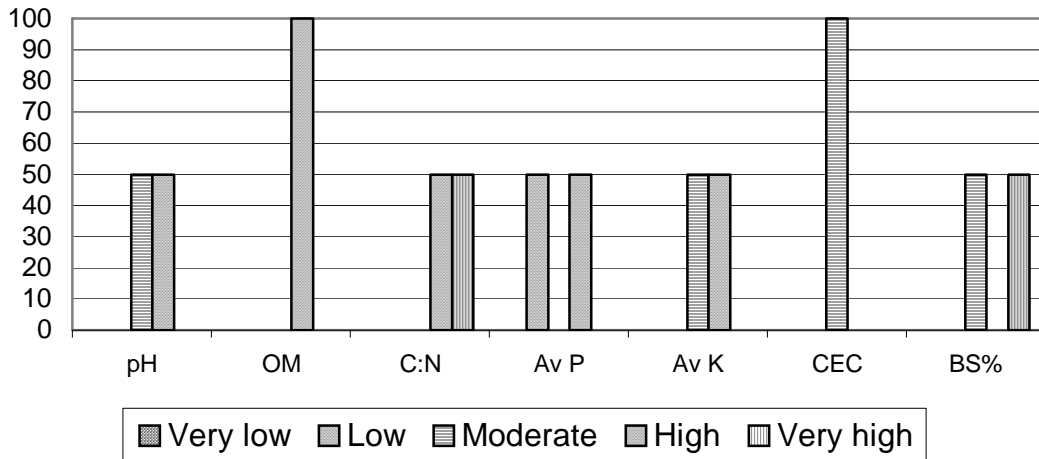


Figure 6 Soil parameters of potato fields in Gomchenbu village.

iv. Soil result of Khesung village (see figure7)

The pH of the soils of this village is all within the medium (pH 5.5-6.5) range. About 85% of these soils have low available K contents (<40mg/kg). About 30% of these soils have very low available P (<5mg/kg) while another 50% of these soils have low P contents (5-15mg/kg). This figure suggests that there is a need to apply P containing fertilizers such as SSP and K containing fertilizers such as MoP to improve the nutrient status of these soils as the K levels are also fairly low. The organic matter content of these soils is high (> 5%) while the C:N ratio is very high (>12).

The CEC of these soils is within the medium range (15-25 meq/100g). The BS% range of these soils is evenly distributed from very low to very high range with almost 30% each in the low to very low ranges. The major soil type is loam and clay loam (figure18). This soil type is of medium textured soils containing less than 40% clay content.

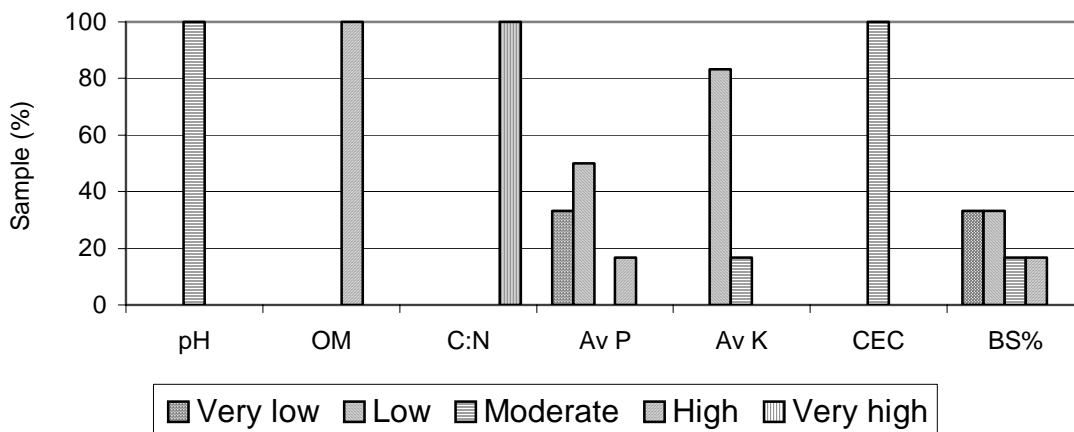


Figure 7 Soil parameters of potato fields in Khesung village.

v. Soil result of Yangertse village (see figure 8)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) while the available K is also in the medium (100-199mg/kg) range. More than 50% of these soils have low available P (5-15mg/kg). This figure suggests that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils though the K levels are fairly adequate. The organic matter content of these soils is mostly within the medium to high ranges with very high C:N ratio (>12).

The CEC of these soils is mostly within the low (5-15 meq/100g) to medium (15-25 meq/100g). The BS% range of these soils is evenly distributed from very low to very high range with almost 60% in the very high range (>80%). The soil type is clay loam (figure18). This soil type is of medium textured soils containing less than 40% clay content.

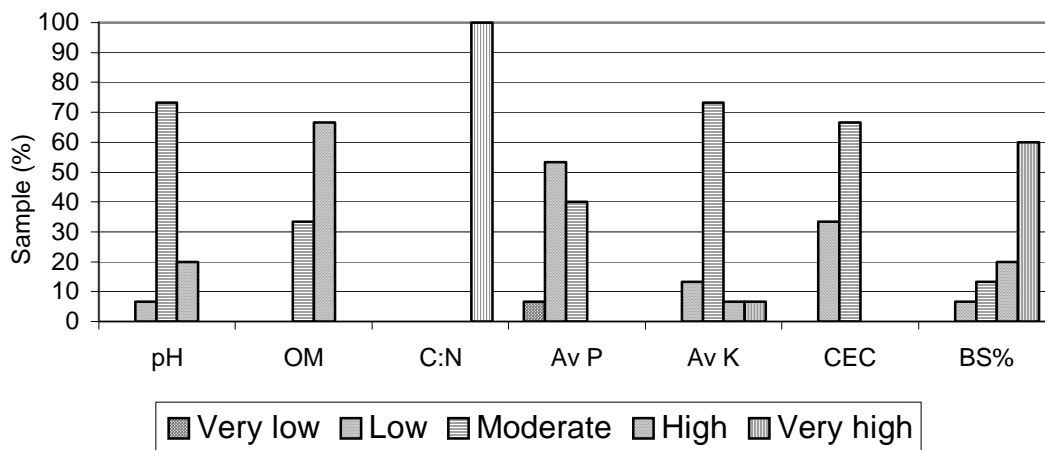


Figure 8 Soil parameters of potato fields in Yangertse village.

vi. Soil result of Bazor village (see figure 9)

More than 80% of these soils have high pH values (pH 6.5-7.5). The available K is in the medium (100-199mg/kg) to high (200-299mg/kg) range) and the available P content of these soils is also in the medium to high range. The organic matter content of these soils is also within the medium range while the C:N ratio is very high (>12).

The CEC of these soils is mostly within the low to medium (15-25 meq/100g) range. In soils with low CEC values, all major macro and micronutrients may be required to attain adequate growth and thereby yield. The BS% range of these soils is very high. The major soil type is clay loam (figure18), which is a medium textured soil containing less than 40% clay content.

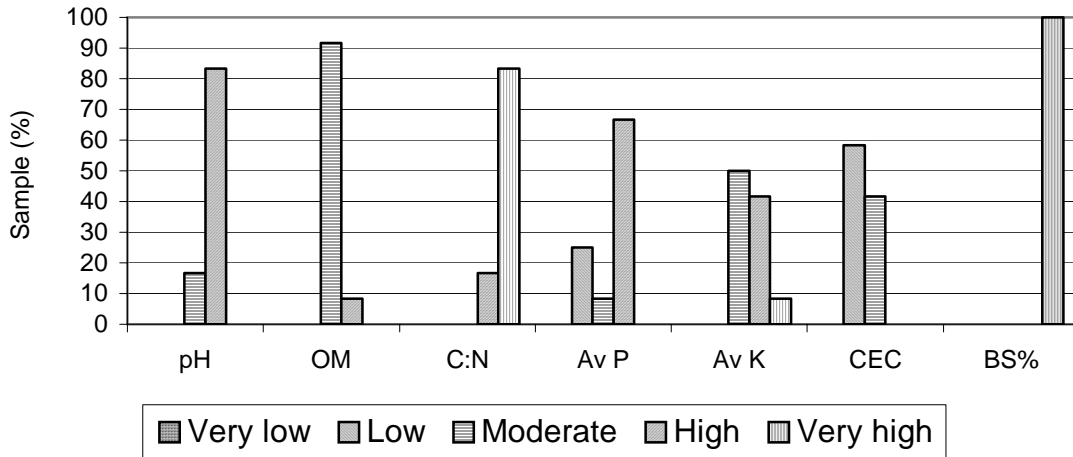


Figure 9 Soil parameters of potato fields in Bazor village.

vii. Soil result of Shafangma village (see figure 10)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) to high (pH 6.5-7.5) range. The available K is in the medium range (100-199mg/kg) with about 20% in the low range. More than 40% of these soils have low available P (5-15mg/kg) and about another 40% have high P contents. This figure suggests that there is a need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils. The organic matter content of these soils is of medium range with very high C:N ratio (>12).

The CEC of these soils is mostly within the low range and in soils with low CEC values, all major macro and micronutrients may be required to attain adequate growth and thereby yield. The BS% range of these soils is very high range (>80%). Clay loam is the prominent soil type found in this village. This soil type is of medium textured soils containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

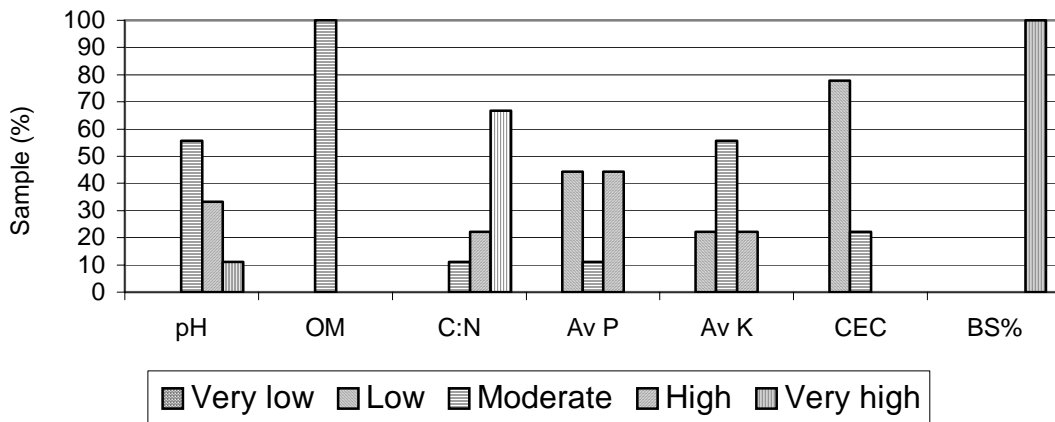


Figure 10 Soil parameters of potato fields in Shafangma village.

viii. Soil result of Shadang village (see figure 11)

The pH of the soils of this village is mostly within high (pH 6.5-7.5) range. The available K is in the medium (100-199mg/kg) to high (200-299mg/kg) range). The available P of these soils is also high (>30mg/kg). The organic matter content of these soils is within the medium range with very high C:N ratio (>12). The CEC of these soils is mostly within the low to medium range (15-25 meq/100g) with very high BS%. Silty clay loam is the major soil type in this village.

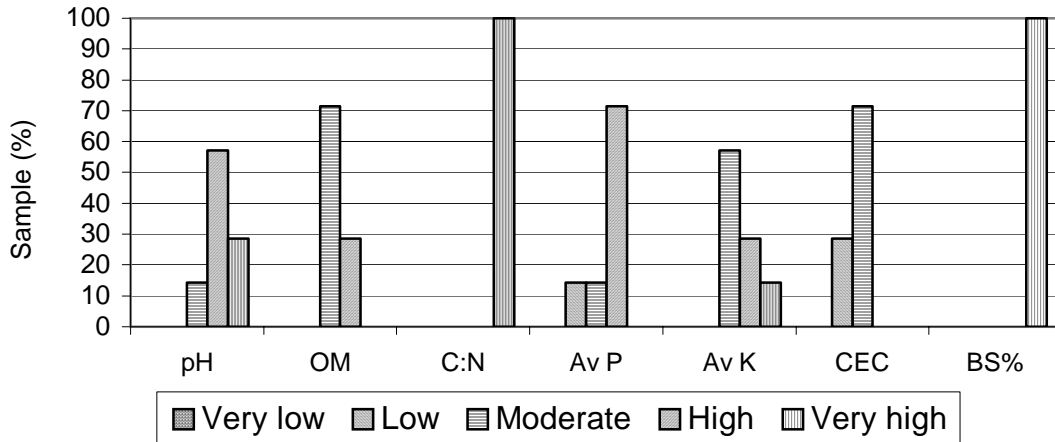


Figure 11 Soil parameters of potato fields in Shadang village.

ix. Soil result of Baging village (see figure12)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) to high (pH 6.5-7.5) range while the available K is in the low to medium range (100-199mg/kg) with almost 40% of these soils in the low range. The available P content of these soils is also within the low to medium range and these figures suggest that there is a 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 content of these soils is within the medium range with very high C:N ratio (>12). The CEC of these soils is mostly within the low to medium range while the BS% range of these soils is evenly distributed from very low to very high range with more than 60% in the high range (65-79%). The major soil type is silty loam (figure18), which is of medium textured soils containing less than 40% clay content.

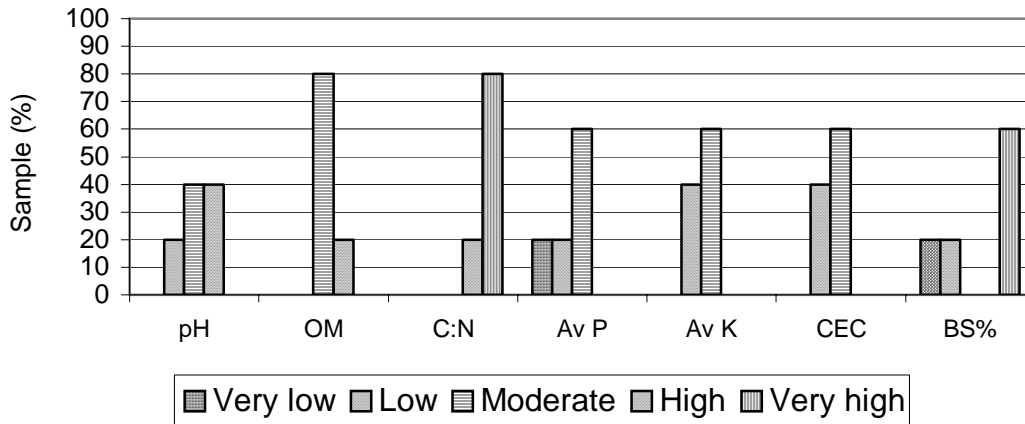


Figure 12 Soil parameters of potato fields in Baging village.

X. Soil result of Khueysingmu village (see figure 13)

In this village, the soil pH is of medium range while the organic matter content is high. The C:N ratio is very high. The available K, CEC and BS% is all within the medium range while the available P is low and hence the need to apply P containing fertilizers such as SSP to improve the nutrient status of these soils. Clay is the major soil type found in this village and in such heavy soils there is usually drainage, structural and infiltration problems.

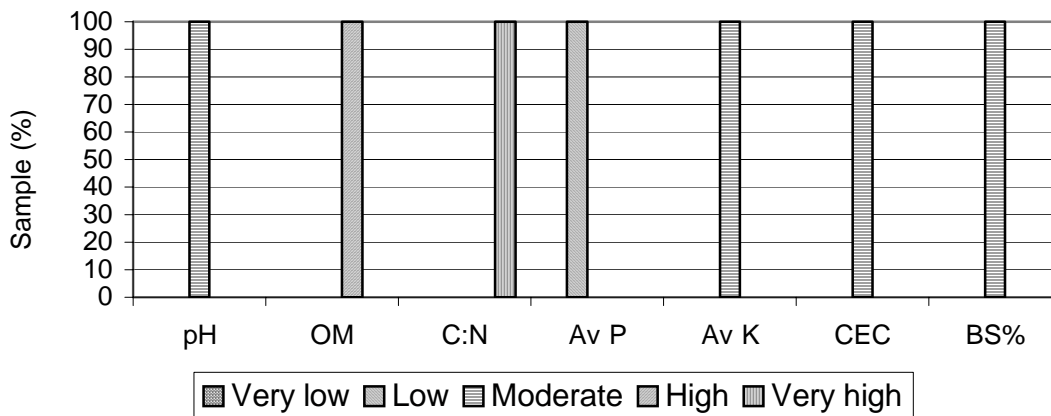


Figure 13 Soil parameters of potato fields in Khueysingmu village.

xi. Soil result of Lebri village (see figure 14)

The pH of the soils of this village is mostly within the medium (pH 5.5-6.5) to high (pH 6.5-7.5) range. The available K is in the medium (100-199mg/kg) range while the available P is low (5-15mg/kg). These figures suggest that there is a need to apply P containing fertilizers such as SSP and K containing fertilizers such as MoP to improve the nutrient status of these soils though the K levels are fairly adequate, potatoes remove a lot of K and hence the need to replenish it. The

matter content is high (> 5%) while the C:N ratio is very high (>12). The CEC and BS% of these soils are of medium range. Silty clay loam is the major soil type in this village (figure18). This soil type is of medium textured soils containing less than 40% clay content.

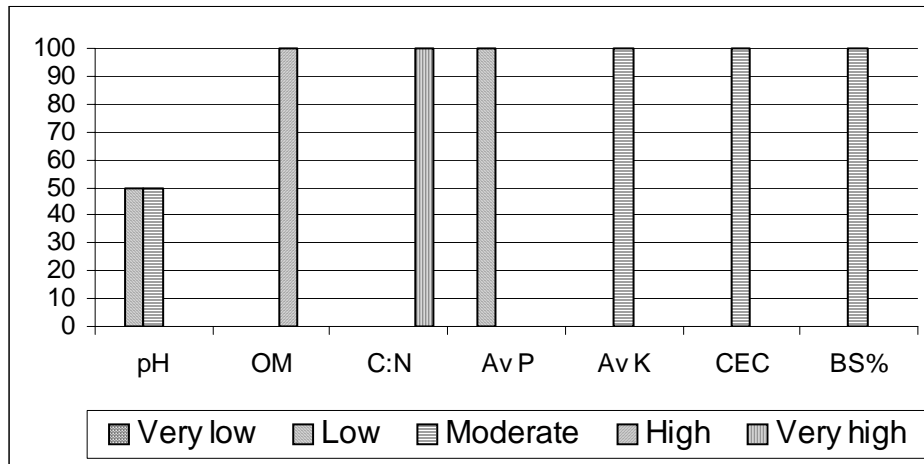


Figure 14 Soil parameters of potato fields in Lebri village.

xii. Soil result of Drametse village (see figure 15)

The pH of the soils of this village is mostly within the medium range (pH 5.5-6.5). Both the available K and P are in the low to medium range. Therefore they 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 of medium range while the C:N ratio is very high. The CEC and the BS% of these soils are mostly within the low to medium range. Coarse-textured soils lack both nutrient and water holding capacities while fine-textured soils often have structural and infiltration problems. Clay loam and sandy clay loam are the major soil types of this village (figure18). Such soil types are of medium textured soils containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

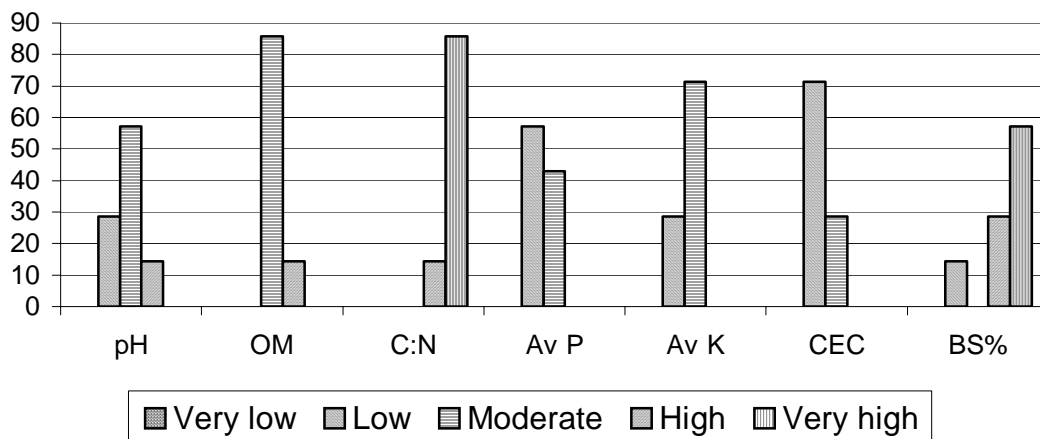


Figure 15 Soil parameters of potato fields in Drametse village.

xiii. Soil result of Gope village (see figure 16)

The pH of the soils of this village is mostly in the high range. The available K is mostly in the low to medium range with more than 40% in the low range. The available P is also within the low to medium range and therefore these figures suggest 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 is of medium range with very high C:N ratio. The CEC of these soils is mostly within the low to medium range while the BS% is very high. Silty loam, a medium textured soil containing less than 40% clay is the major soil type of this village (figure18).

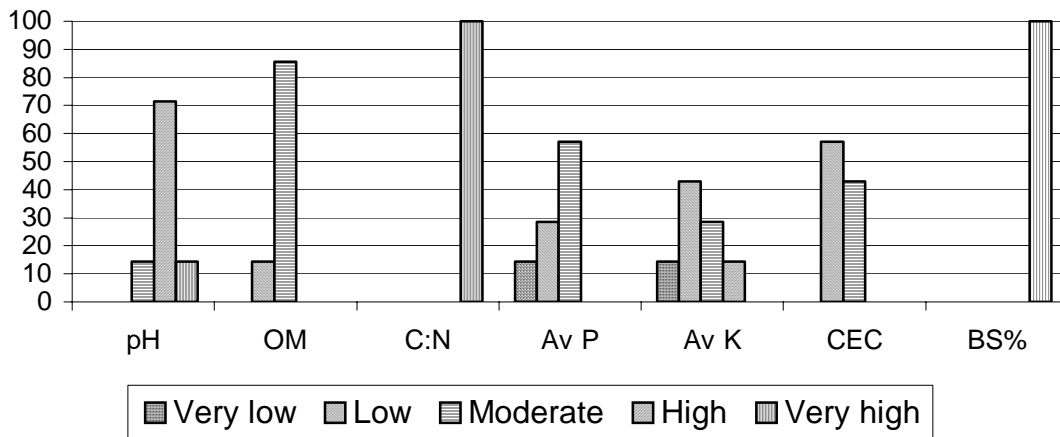


Figure 16 Soil parameters of potato fields in Gope village.

xiv. Soil result of Zangkhar village (see figure 17)

The soil pH of this village is mostly within high range (pH 6.5-7.5). The available P is mostly within the very low to medium range with almost 40% of these soils in the very low range. The available K is also within the low to medium range though more than 70% are within the medium range. These 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 in these soils is also within the low to medium range while the C:N ratio is between the medium to very high range. More than 90% of these soils have low CEC values and such soils with low CEC content all major macro and micro nutrients may be required to attain optimum growth and yield. However, the BS% is of very high range. Coarse-textured soils lack both nutrient and water holding capacities while fine-textured soils often have structural and infiltration problems. There are four major soil types found in this village viz. clay loam, silty clay loam, sandy clay loam and silty loam (figure18). All these soil types are of medium textured containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

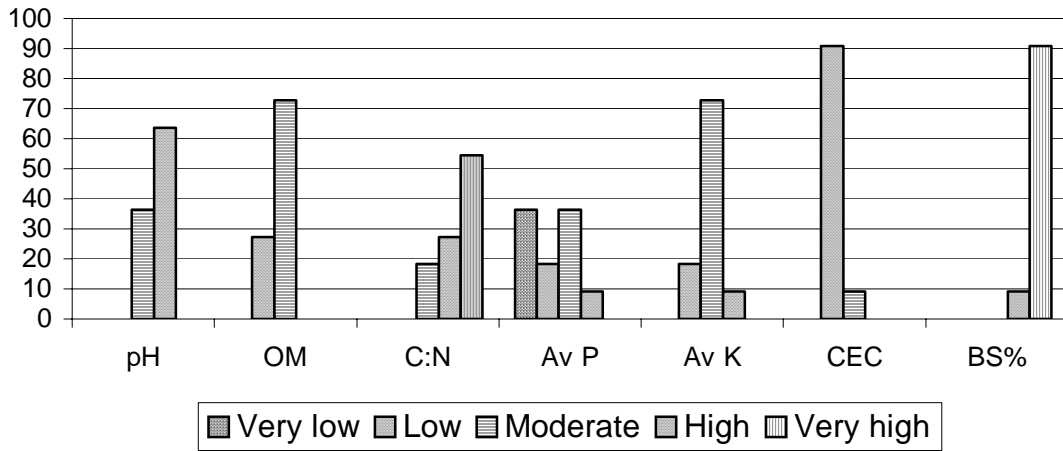


Figure 17 Soil parameters of potato fields in Zangkhar village.

xv. Soil texture of different villages under Drametse geog (see figure 18)

The different soil textures found in each village under Drametse geog is presented in the following figure.

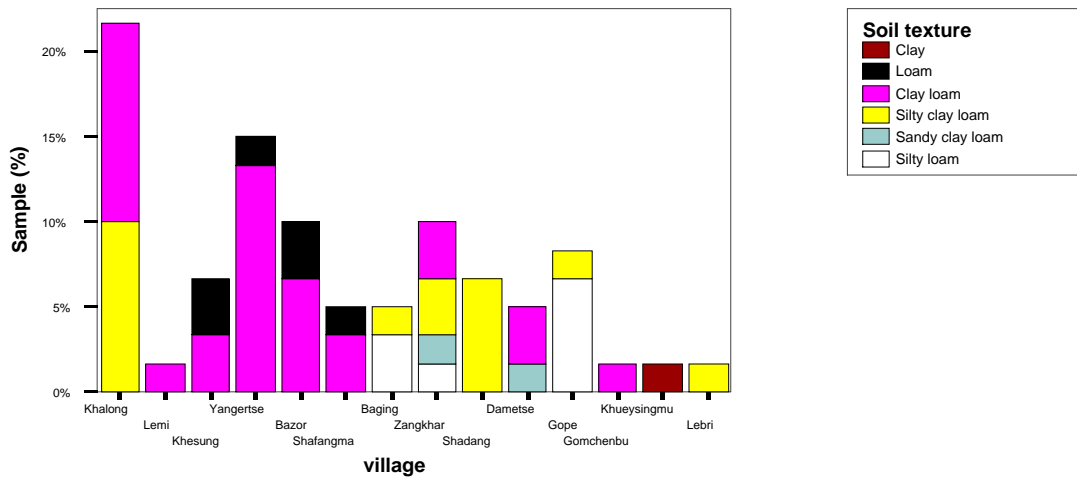


Figure 18 Soil textures of potato fields in different villages (Drametse geog).

4. Conclusions

In Drametse geog the potato fields are mostly located at low altitude with the majority of the plots on steep slopes with aspects facing NE and with small land holdings. Desiree is the most preferred potato variety grown by the farmers, which is planted in the month of February. Potato is intercropped with maize, which is sown one month after planting potato. All the farmers apply only FYM (about 16.6t/ac) to potato. No other inorganic fertilizer with the exception of urea (by few farmers only) is applied to maize as a single top dress during pre-tasselling of maize. FYM is usually broadcasted prior to ploughing. The average yield of potato and maize is 3.9t/ac and 3.6t/acre respectively. Tethering of cattle is not practiced while all the farmers burn the crop residues prior to land preparation. Weeding is done at least twice by all the farmers.

Most of the plots have the ideal pH range while the available P content of these soils is mostly within the low range to moderate range. In this geog, 10 villages^{iv} out of 14 have very low-to-low available P values. The available K of this geog is mostly within the medium range though few villages like Khesung, Baging, Drametse and Gope have low K values. Therefore, there is the need to apply the P and K containing fertilizers to improve the soil nutrient status and hence the yield. Most of the soils have high BS% and the CEC content of these soils is within the low to medium range and hence the need to increase its CEC content. The major soil type is clay loam and 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.

- ☞ The available P content of these soils in most of the villages is low and this could be improved by applying P containing fertilizer such as SSP together with urea as a basal dose.
- ☞ The available K content of these soils is mostly within the medium range and though it might be adequate, there is the need to apply K containing fertilizer such as MoP to replenish the K content of these soils as potatoes are efficient removers of K.
- ☞ The CEC of these soils is within the medium range and therefore there is also the need to improve its nutrient content as all the major macronutrients are required to obtain adequate yield and hence an application of balanced nutrients with proper recommended rate needs to be encouraged. (i.e. the rate of 90:80:80 kg/ha or 36:32:32 kg/acre of N,P,K is recommended based on the soil result with modifications from the previously recommended rate of 100:80:60 kg/ha of N,P,K or 40:32:24 kg/acre of N,P,K).

The P and K values are slightly increased from the FAO recommended rate, as these values from the soil analysis report are low in this geog while the rate of N is decreased slightly as the farmers apply plenty of FYM. 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.

▪ **Thus the recommended rate of 90:80:80 kg/ha of N,P,K:**

1. Using Suphala is as follows:

- Apply about 216 kg/acre of Suphala as basal dose during land preparation (i.e. about 4 bags of Suphala @50 kg per bag per acre).
- Followed by one application of 9 kg of urea once either when the plants are of 15-20 cm high (i.e. 30-45 days after planting) or at the time of flowering of potato (or when the maize plants are of knee high stage if intercropped with maize).

2. Using SSP, MoP and Urea¹ 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 202kg/acre of SSP as basal dose during land preparation (i.e. 4 bags of SSP @ 50 kg per bag per acre).
- Apply about 54kg/acre of MoP as basal dose during land preparation (i.e. about 1 bag of MoP @ 50 kg per bag per acre).
- Followed by about 9kg 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 flowering (i.e. maize plants are of knee high stage).

☞ In addition to this the major soil type is of medium textured and so a split application of urea is even more advisable for better utilisation of the N nutrient.

☞ In addition, 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.

ⁱ According to FAO reports.

ⁱⁱ FAO recommendations

ⁱⁱⁱ SSF&PNM based on FAO recommendations.

^{iv} Viz. Khesung (80%), Gomchenbu (50%), Yangertse (50%), Shafangma (40%), Baging (40%), Khueysingmu (100%), Lebri (100%), Drametse (almost 55%), Gope (40%) and Zangkhar (50%).

¹ 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.