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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, potato based system in Bumthang Dzongkhag and major citrus growing areas of Tsirang and Dagana Dzongkhags. Soil samples are 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-maize growing Dzongkhags next to Trashigang and Pemagatshel Dzongkhags. Though potatoes are grown throughout the Dzongkhag, one of the most intensively cultivated area is under Drametse geog.

In continuation to the first batch of soil samples (collected in December 2002), a second batch of soil samples were collected by the staff of National Soil Services Centre (NSSC) together with geog RNR staff from Drameste geog under Monggar Dzongkhag in Nov-Dec 2008. A total of 69 soil samples were collected from this geog.

2. Method

The group collected the soil samples from the farmers' fields based on the list from the First Batch of samples collected in 2002. A total of 69 households were selected from the initial 98 households. The main criteria for downsizing the number of samples was based mainly on the clustered plots where a representative sample could be taken and also few scattered households were not included. Prior to sampling, 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 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 bags labeled properly and the samples 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 16 for windows.

3. Results and discussions

In the first half of the report, the general observations as recorded during the survey and the average soil analysis result of the geog is presented while in the second half soil results from individual villages with fertilizer recommendations is presented.

3.1 Sample households

In Drametse geog, a total of 69 household covering 11 villages[a] were sampled. The highest number of respondents was from Yangertse village (20.3%) followed by Khalong (15.9%), Shafangma (10.1%)

[a] Villages under Drametse geog: Baging, Bazor, Drametse, Gomchenbu, Gope, Khalong, Khesung, Shadang, Shafangma, Yangertse, Zangkhar

villages**.** Gomchenbu village had the lowest number of respondents (just 2.9%). These figures suggest that there could be more farmers growing potatoes in Yangertse, Khalong villages compared to Gomchenbu village. The various management practices and other site parameters in addition to the soil results are presented below**.**

3.2 Site description 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, the majority of the plots (50.7%) are situated on moderately sloping areas followed by steep slopes (37.7%) and few plots on level (1.4%) and gently sloping (1.4%) areas. The majority of the plots are north-westerly and north-easterly facing aspects with 89.9% and 85.5% respectively. More than 50% of the sampled plots are located at medium altitude range (between 2000 and 3000 m.asl) and the rest at the low altitude range (less than 2000 m.asl). The majority of the farmers (more than 80%) of the samples sites have small plot sizes (< or =1 acre). All the farmers of this geog grow potatoes in their own fields (100% owned) unlike in other geogs where the plots are either shared in or shared out. The majority of the farmers (87.3%) grow the red variety (i.e. Desiree), while very few farmers (less than 2%) grow Yusikarp and the rest grow both the varieties. About 73% of the farmers start planting potatoes in February though few farmers' plant as early as January and as late as March.

3.3 Crop 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.

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 16-20 tac^{-1}[b] though on an average, the yield is about 7-8 tac^{-1}.

From Figure 1 it can be observed that the maximum potato yield (tac^{-1}) is reported from Shafangma with 5.4 tac^{-1} followed by Drametse and Shadang villages with 3.62 tac^{-1} and 3.35 tac^{-1} respectively. The lowest yield is reported from Gope and Baging villages with 1.26 tac^{-1} and 1.34 tac^{-1} respectively. On an average, the potato and maize yield from Drametse geog is 2.8 tac^{-1} and 2.32 tac^{-1} respectively. These figures suggest that the potential yield level has not been attained yet. However, the farmers of this geog reported that the maize production is quite adequate for their daily consumption.

[b] According to FAO reports

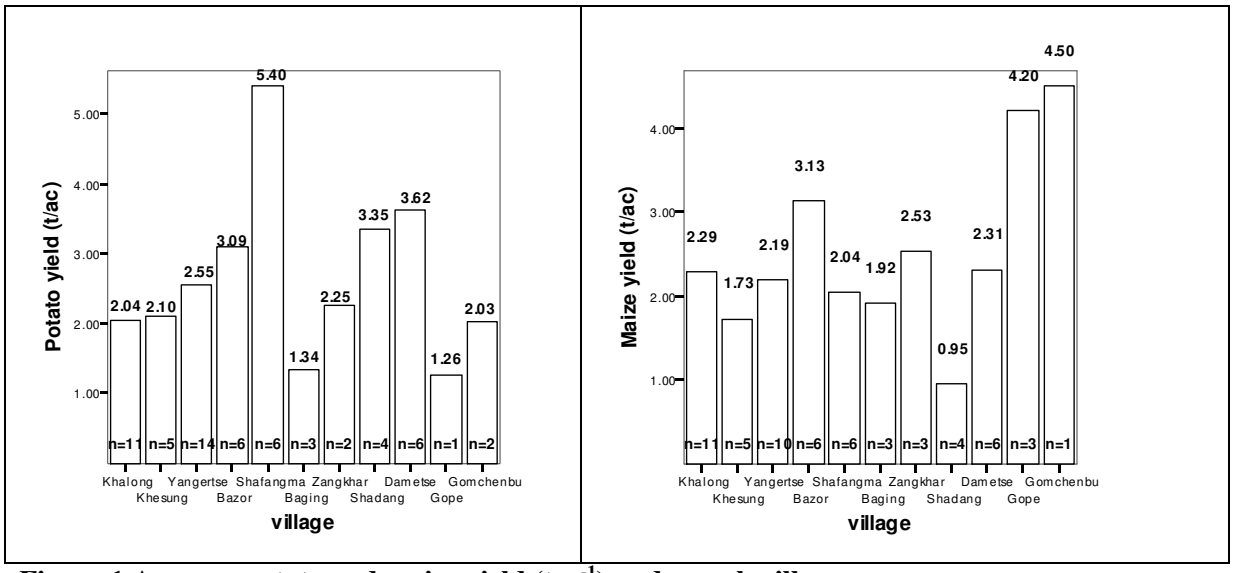


Figure 1 Average potato and maize yield (tac^{-1}) under each village

In Drametse geog, the majority of the farmers (almost 70%) reported that they have changed the potato seed. About 43% have changed their seeds during the last 5 years while the rest of the farmers have changed their seeds quite long time back (some even more than 15 years). About 29% of the farmers have not changed their seed at all.

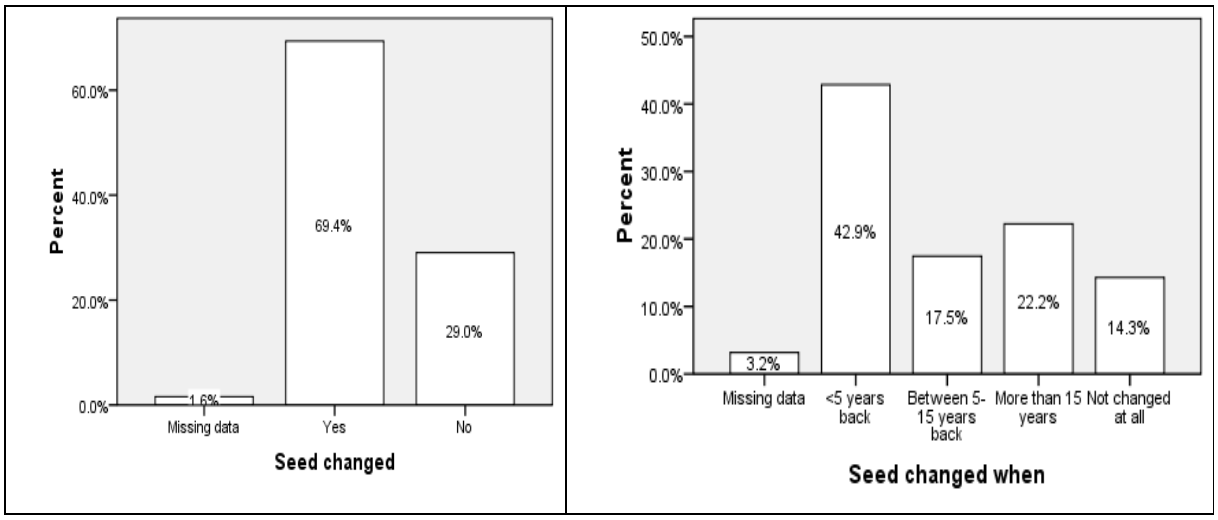


Figure 2 Potato seed changed and when was it changed?

3.3.1 Crop yield in relation to inorganic fertilizers application

From the following figures, it shows that there is a positive yield response with increasing rates of suphala application for potato. The maximum potato yield was about 5.4 tac^{-1} when suphala application rate was between 201-300 kgac^{-1} (reported by one farmer). The majority of the farmers of this geog reported potato yield of 3.37 tac^{-1} with the suphala application rate of 100-200 kgac^{-1}. However, there was no positive response of maize yield with urea application. This could be due to the fact that maize is usually planted after potato and there could a possibility of the residual effect from suphala in addition to urea application in maize.

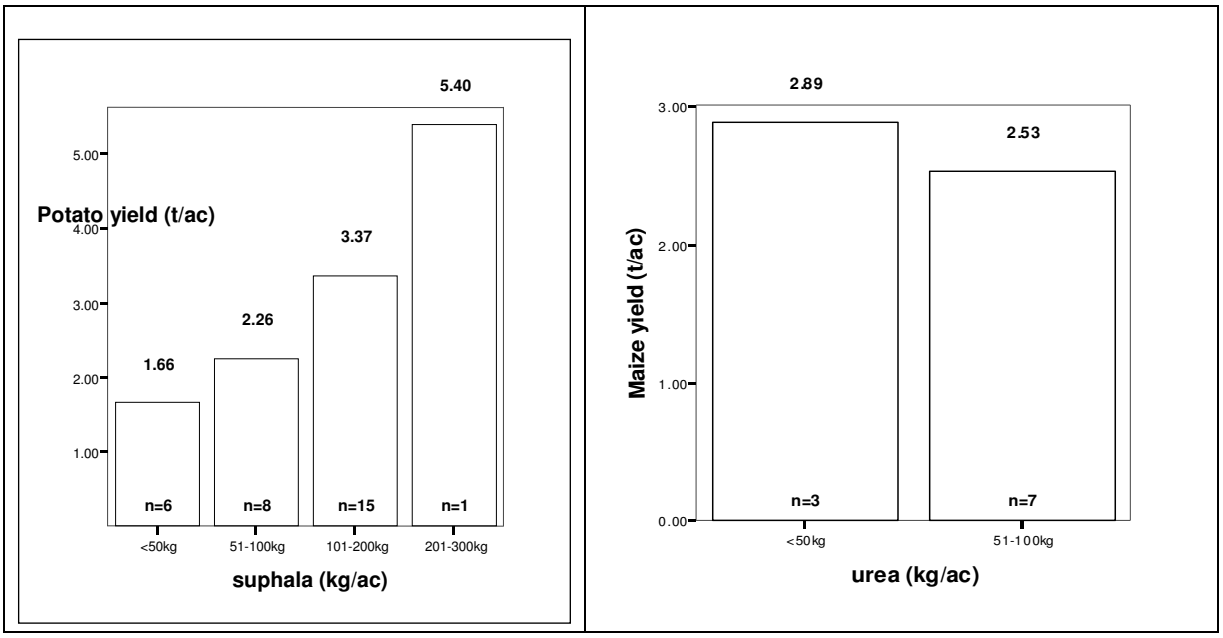
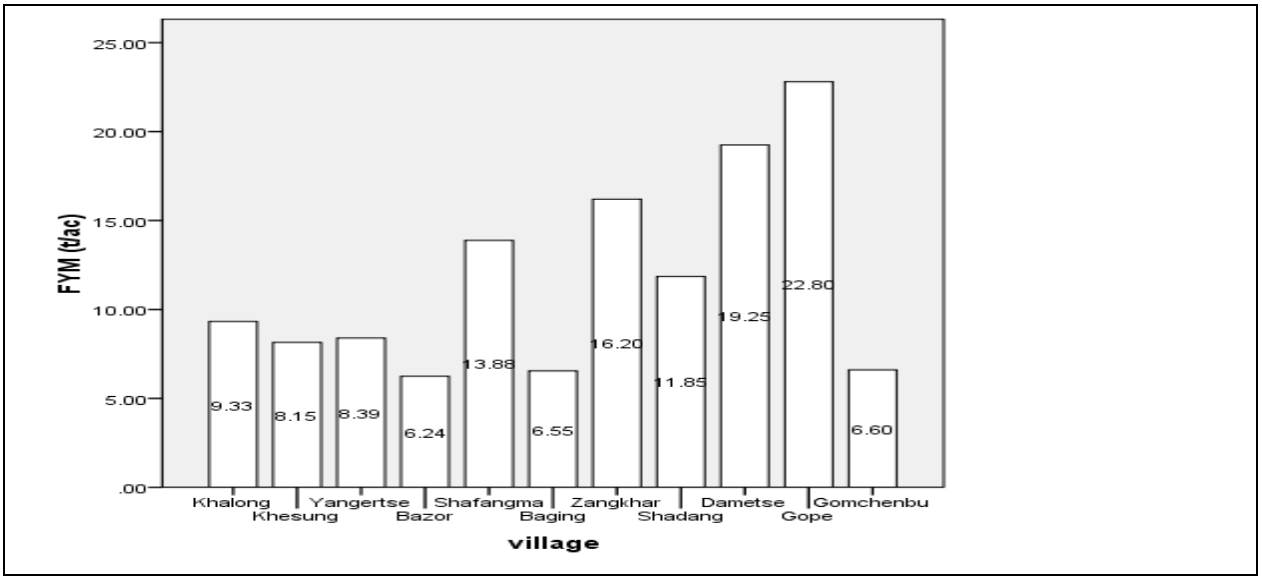


Figure 3 Potato & maize yield in relation to inorganic fertilizer applied in the geog

3.4 Soil fertility management practices.

3.4.1 Farm Yard Manure (FYM)

In Drametse geog, about 98% of the farmers apply Farm Yard Manure (FYM) to their fields with an average application of 11.1 t dry matter ac^{-1} (equivalent to 152 kg N ac^{-1}, 32 kg P ac^{-1}, 219 kg K ac^{-1}, 260 kg Ca ac^{-1})[c] . At a mean recorded FYM dry matter of 50% this means that FYM application rate is 22.2 t ac^{-1}. FYM is usually broadcasted on the fields and incorporated into the soil by ploughing during land preparation. The highest rate of FYM application (tac^{-1}) is one farmer from Drametse village (64.52 tac^{-1}) followed by another farmer from Gope village (42 tac^{-1}).



[c] Mean FYM dry matter nutrient content is 1.38%N, 0.29%P, 1.97%K, 2.35% Ca (Source: SSF&PNMP,2001).

Figure 4 Amount of FYM applied (tac^{-1}) under each village.

3.4.2 Inorganic fertilizers

The survey findings indicate that about 55% of the farmers apply inorganic fertilizers to potato and maize quite contrary to the first batch of samplings where almost all of the farmers did not apply any inorganic fertilizers. The average suphala application rate of this geog is 117.3kg ac^{-1} which is equivalent to 17.6 kgac^{-1} NPK. The highest rate of suphala application to potato is from Yangertse village at the rate of about 167 kg ac^{-1} (which is only about 25 kgac^{-1} of NPK) and this rate is way below the recommended rate for potato (RR is 36:32:12 kg ac^{-1})[d]. Urea is not applied to potato though it is applied to maize.

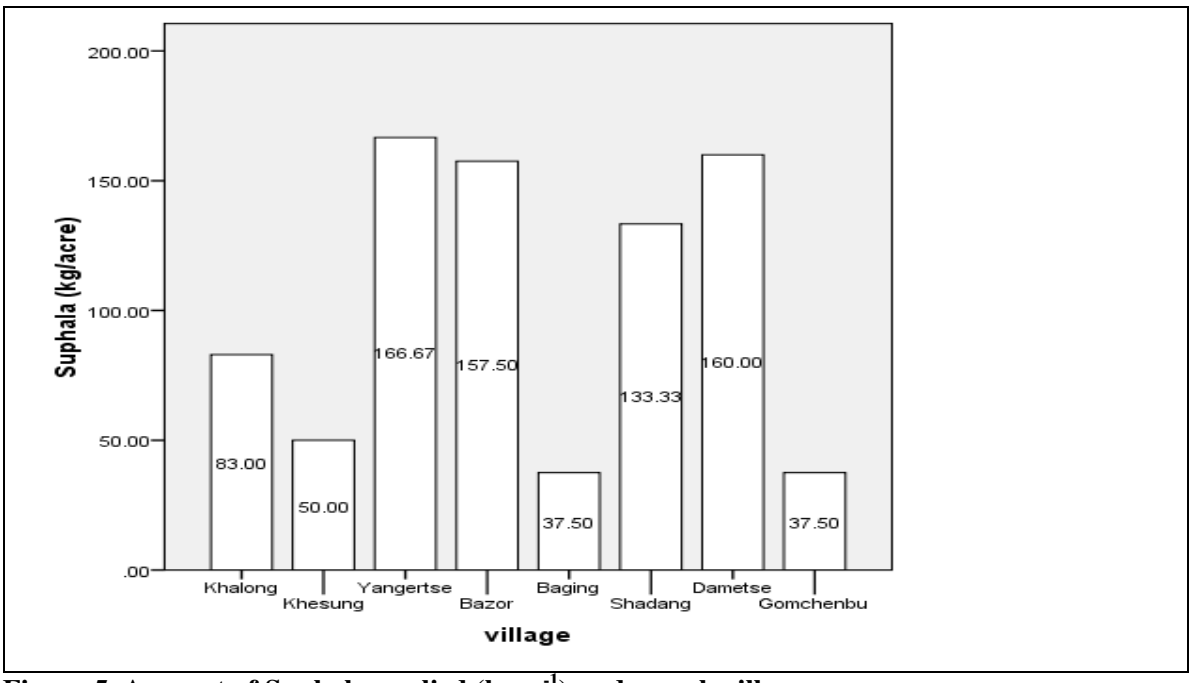


Figure 5. Amount of Suphala applied (kgac^{-1}) under each village.

On average, the farmers apply about 67kg ac^{-1} of urea which is equivalent to about 31kg N ac^{-1}. The maximum application of urea (80 kgac^{-1}) is from Khalong village which is equivalent to 36.8 kg N ac^{-1} and the lowest application rate of 26 N ac^{-1} is reported from Drametse geog (equivalent to 12 kg N ac^{-1}).

[d] RR=Recommended Rate for Low Resource farmers of Trashigang; High resource farmers is 40:32:32 (Source : NSSC, 2008)

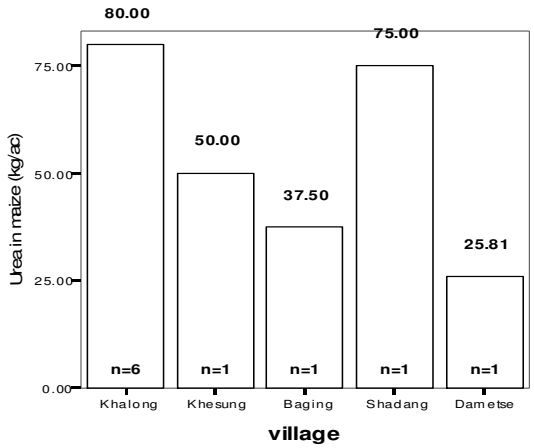


Figure 6a. Amount of urea applied (kgac^{-1}) under each village

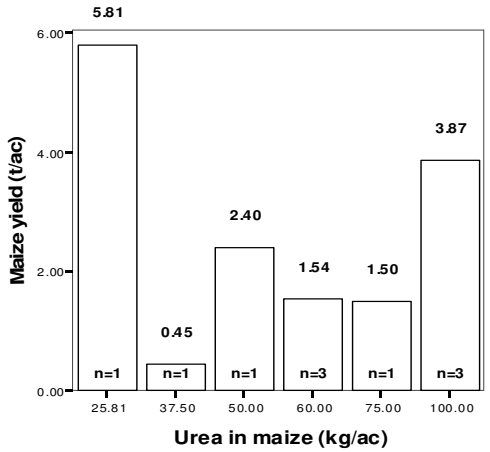


Figure 6b. Maize yield vs Urea applied

Potatoes respond well to moisture, however, irrigation at tuber initiation can affect the skin quality of daughter tubers by influencing phytopathogens, either favourably or adversely according to conditions**,** and amount of moisture present. However, in this geog, no irrigation is done and is completely rain fed.

3.5 Soil analytical 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 and micronutrients) very low and low classifications indicate a high probability for obtaining a good fertilizer response; moderate classifications indicate a fertilizer response may or may not occur while a high to a very high classifications indicate that 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 applying only urea leads to rapid depletion of soil reserves of other nutrients such as P and K etc.

3.5.1 Soil pH

The following figure 3 shows the soil parameters of the geog. The soil pH is generally categorized into five categories viz. very high (>7.51), high (6.51 to 7.5), medium (5.51 to 6.5), low (5.01 to 5.5) and very low (<5.0).

The majority (more than 65%) of the soils have moderate/medium pH range. Potatoes are grown on organic as well as mineral soils. Soil pH requirement of minimum 5.5 but below about pH 4.8 growth is impaired. Alkaline conditions (pH above 7.0) can adversely affect skin quality and highly alkaline conditions can induce micronutrient deficiencies.

3.5.2 Organic Matter content (OM%)

Organic matter serves as a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and increases water infiltration into the soil. The organic matter content of the

soils in this geog is within the moderate to high range. Usually the organic matter content of the soils can be increased by applying farm yard manure and other organic material into the soil.

3.5.3 Available phosphorus (P)

As in all plants, potatoes also need phosphorus for good growth and yield and do respond well to P fertilizer application if the soil test results show low values.

The available P has been categorized into five ranges, viz. very low (<5 $mgkg^{-1}$), low (5-15 $mgkg^{-1}$), medium (15-30 $mgkg^{-1}$), high (30-35 $mgkg^{-1}$) and very high (>35 $mgkg^{-1}$).

More than 65% of the samples have moderate/medium available P while about 15% each of the samples have low and high values. Usually for available P values with low to medium range, there is a possibility of a good yield response with P application.

3.5.4 Available potassium (K)

As any other crops, potatoes also require adequate amounts of N,P,K for optimum crop yield. Potatoes require large amounts of K as it plays an important role in photosynthesis and starch production. Potatoes are efficient extractors of K and therefore the need to apply more K to the soil if the soil test results show low values.

Available K is also categorized into five ranges viz. very low (<40 $mgkg^{-1}$), (40- 100 $mgkg^{-1}$), medium (100-200 $mgkg^{-1}$), high (200-300 $mgkg^{-1}$) and very high (>300 $mgkg^{-1}$).

The available K of this geog is within the medium to high range. No K fertilizer recommendation could be made for those with high values but for those within the low to medium range it would be advisable to apply K containing fertilizers to the soil.

3.5.5 Nitrogen (N)

Potatoes require high amounts of nitrogen during a short period of time and potatoes also use large amounts of N, frequently more than the total applied as fertilizer (Anderson & Hewgill, 1978). Nitrogen is important for potato and its deficiency induces poor plant growth and crop yield besides accentuating certain diseases such as early blight and *Verticillium* wilt. On the other hand, excess N can delay the onset of tuber growth, increase knobby potatoes and promote excess vine growth.

On an average, the nitrogen content of the soils in this geog is very low. This could probably indicate the loss of nitrogen from the soil through leaching, volatilization due to improper application method and/or timing or inadequate application of nitrogen containing fertilizers.

3.5.6 Carbon : Nitrogen (C:N) ratio

The C:N ratio basically indicates the type of organic matter present in the soil and more so the degree of humification. In the tropics, the C:N ratio is lower due to rapid decomposition than in the temperate regions. Crop residues such as straw have high C:N ratios while legumes have low ratios.

The C:N ratio has been categorized into five ranges viz. very low (<6), low (6-8), medium (8-10), high (10-12), very high (>12). For the Drametse geog, the C:N ratio is within the high (15%) to very high (85%) range.

3.5.7 Cation Exchange Capacity (CEC)

The CEC is the measure of the capacity of the soil to hold exchangeable cations (nutrients) and is used to assess the overall fertility potential of the soil. The CEC has been categorized into five ranges, viz. very low (<5 meq100g^{-1}), low (5-15 meq100g^{-1}), medium (15-25 meq100g^{-1}), high (25-40 meq100g^{-1}), very high (>40 meq100g^{-1}). Usually, a soil with a high CEC value (>25 meq/100g) is a good indicator that a soil has high clay and/organic matter content and can hold lots of cations while a soil with a low CEC value (<5meq/100g) is a good indication that a soil is sandy with little or no organic matter that cannot hold many cations. Normally a soil with high CEC values is considered more fertile than the ones with low values.

On an average, the CEC of this geog falls within the medium range.

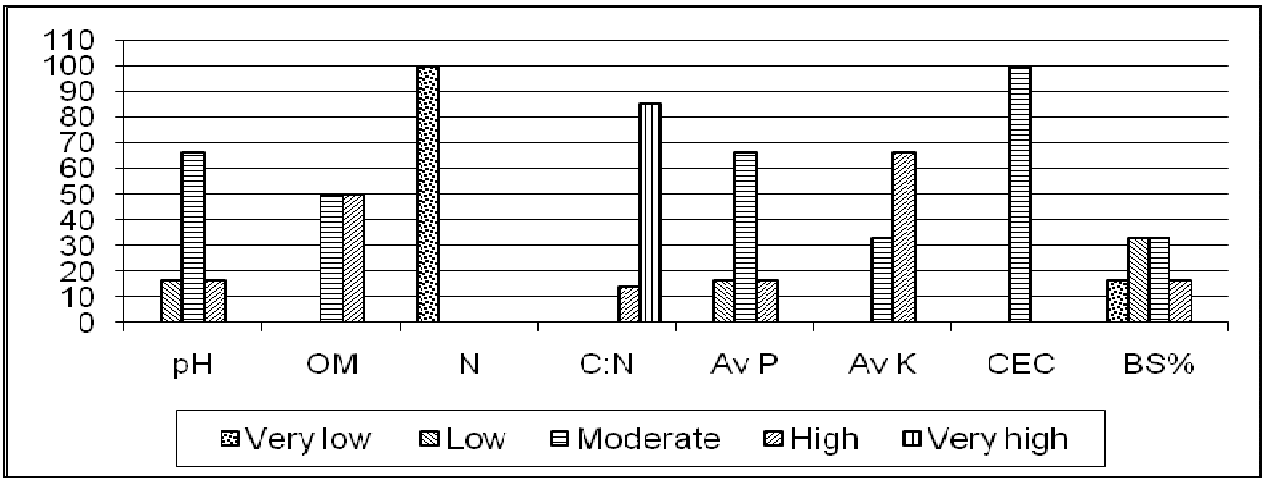


Figure 7. Soil parameters of potato fields under Drametse geog.

3.5.8 Soil Texture

Potatoes can be grown in most soil types where though the greatest productivity is from a deep, loose, crumbly and well-aerated soil. Potatoes have low tolerance to water logging and do not do well in heavy clayey soils. Coarse-textured soils lack both nutrient and water holding capacities while fine-textured soils often have structural and infiltration problems.

Sandy clay loam (SCL) which is a medium textured soil and sandy loam (SL) which is a fine textured soil are the two dominant soil textures of this geog (48% and 39% respectively).

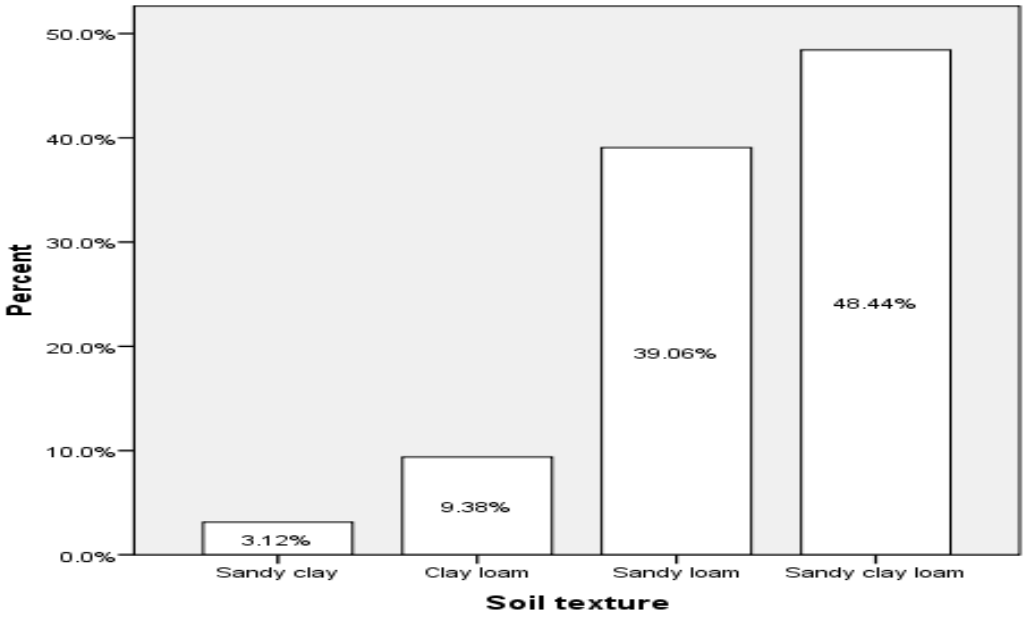


Figure 8 Soil texture of potato fields under Drametse geog (average of all villages)

The soil results of each village under Drametse geog are summarized as follows.

3.6 Soil analytical result of individual village under Drametse geog

3.6.1 Soil result of Khalong village

The pH of the soils of this village is mostly within the low to medium ranges. The organic matter content of Khalong village is mostly within the high range (more than 90% of the samples) and the nitrogen is within the medium range. About 70% of these soils have ***low P and therefore the need to apply P containing fertilizers such as SSP*** and only less than 10% have high P values. About 55% of these soils have high K and about 15% with very high values while the rest have ***medium values and therefore need to apply K containing fertilizers such as MoP.*** The CEC values are mostly within the medium to high range. The BS% range of these soils is distributed from very low to very high range with more than 45% in the medium range.

The major soil type is sandy clay loam and clay loam (Figure 20). This soil type is of moderately fine textured soils.

Figure 9 Soil parameters of potato fields in Khalong village.

3.6.2 Soil result of Gomchenbu village

The pH of the soils of this village is within the medium range which is ideal for growing almost all crops. The soil organic matter content is high for this village though only about 6.6t/ac is applied. The N content is within the medium range. The **available P content of these soils is *very low*** (50% of samples) and the rest is within the medium range. Therefore, to get a good yield, there is ***a need to apply P containing fertilizers such as SSP*** in Gomchenbu village. The ***available K is in the medium*** (50% of samples) to high (50% of samples) and as potatoes are good extractors of K, there is a need to ***apply K containing fertilizers such as MoP*** for those soils with medium K values. The CEC of these soils is all within the medium to high ranges (50% each) while the base saturation is within the very low to medium ranges. Sandy loam and sandy clay loam are the two types of soils in this village (Figure 20).

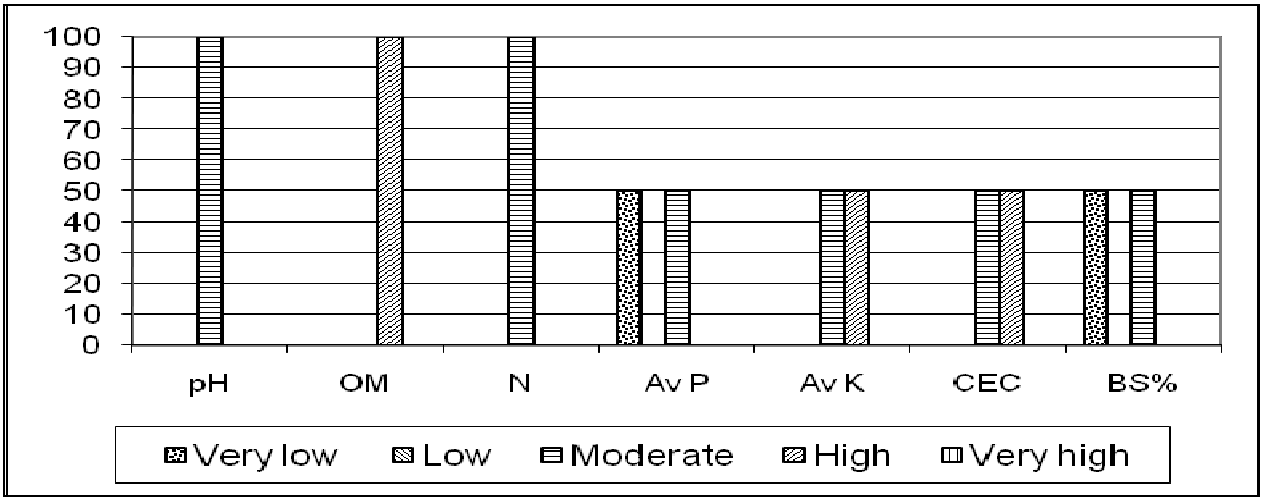


Figure 10 Soil parameters of potato fields in Gomchenbu village.

3.6.3 Soil result of Khesung village

Only about 60% of these soils are with medium pH values while about 20% each are in the low to very low ranges though the organic matter content of these soils is high. The ***available P of these soils is all within the low to very low ranges*** indicating the need to apply P containing fertilizers such as ***SSP or TSP***. The available K content of these soils are mostly within the medium range (about 60% of these soils) while the 20% is within the very low range and therefore need to ***apply K containing fertilizers such as MoP*** to improve the nutrient status of these soils as the K levels are also fairly low.

The CEC of these soils is mostly within the medium range while the BS% range of these soils is within the very low to low ranges. The major soil type of this village is **sandy loam** (Figure 20). This soil type is of moderately coarse textured soils containing less than 30% clay content. In such soils, usually a split application of N is advisable.

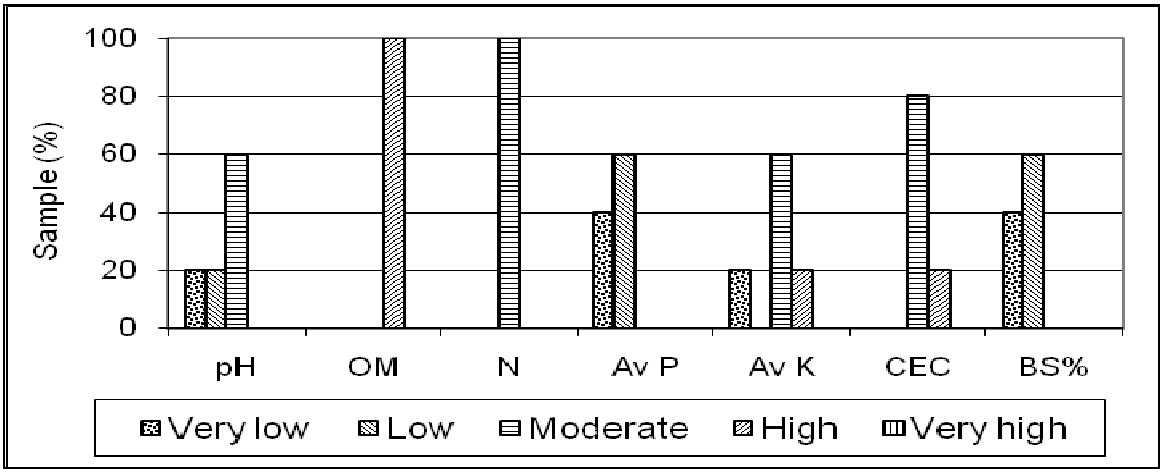


Figure 11 Soil parameters of potato fields in Khesung village.

3.6.4 Soil result of Yangertse village

The pH of the soils of this village is mostly within the medium range (>50% of these samples) while about 20% of the samples have low values and about 8% within the very low range. The organic matter content of these soils is within the medium to high range. The N content of these soils is also within the low to medium range. About 50% of these soils have ***low to very low P values*** though about 27% of them have high values. For those with low to very low values, there is the need to apply P containing fertilizers such as SSP and TSP. The available K is also mostly in the medium range (>60% of the samples) while about 15% are within the ***low range and a need to apply K containing fertilizers such as MoP.***

The CEC of these soils is mostly within the medium to high ranges. The BS% range of these soils is evenly distributed from very low to very high ranges. Sandy loam moderately coarse textured) and sandy clay loam (moderately fine textured) are the two dominant soil types of this village (Figure 20).

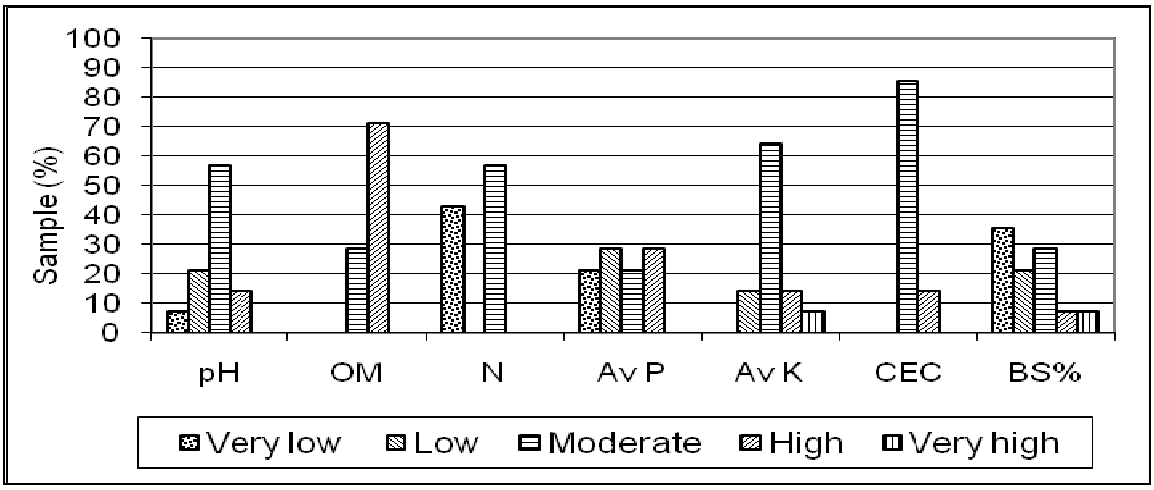


Figure 12 Soil parameters of potato fields in Yangertse village.

3.6.5 Soil result of Bazor village

The pH and the organic matter content of the soils in Bazor village is within the medium range. The available K is in mostly within the high rage and only about ***15% within the low range.*** The available K content of these soils is also within the medium to high ranges though the N content is low for all the soils. The CEC is mostly within the medium range .The BS% range of these soils is within the medium to high ranges. The major soil type is ***sandy loam*** (Figure 20), which is a moderately coarse textured soil containing less than 30% clay content.

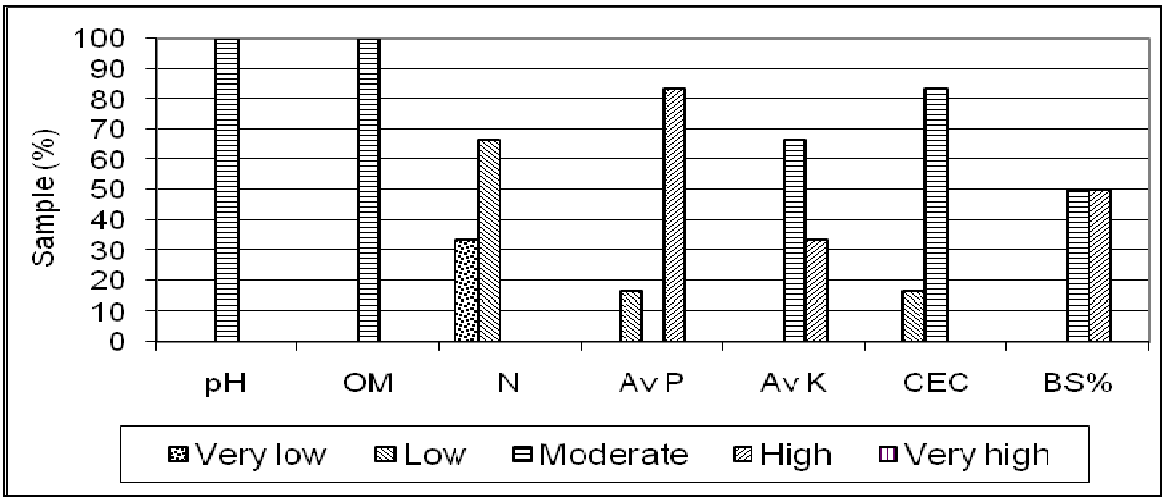


Figure 13 Soil parameters of potato fields in Bazor village.

3.6.6 Soil result of Shafangma village

The pH and the organic matter content of the soils of this village are all within the medium range. The nitrogen is low. The available P is mostly within the medium range and very few within the low range. About 40% of the samples have high K values while about 30% each have low and high values. The CEC of these soils is mostly within the low range to medium ranges 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 almost evenly distributed from low to high ranges. **Sandy loam** is the prominent soil type found in this village (Figure 20).

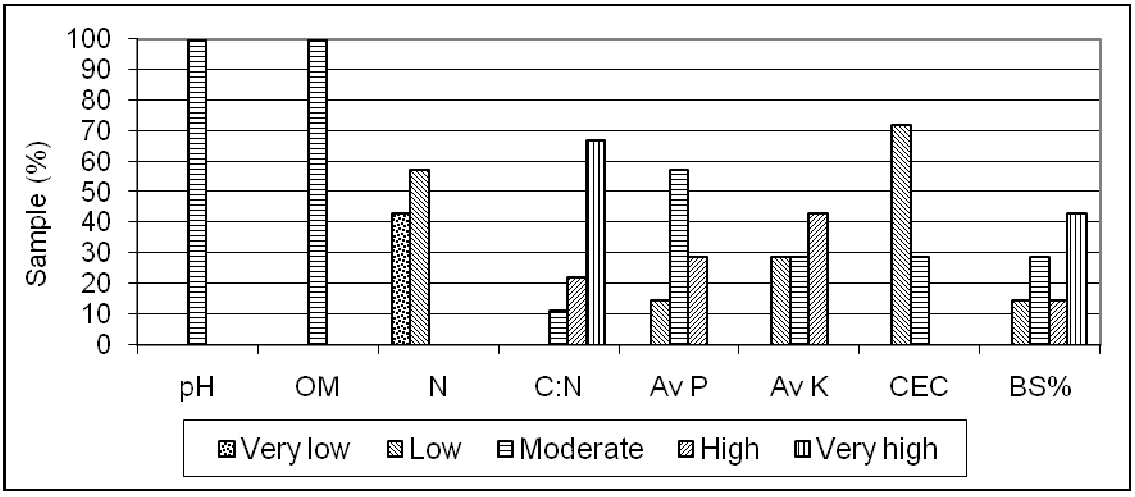


Figure 14 Soil parameters of potato fields in Shafangma village.

3.6.7 Soil result of Shadang village

The pH of the soils of this village is mostly within medium to high ranges. The organic matter content of theses oils is within the medium to high range. ***The available P of these soils is all low*** and therefore the ned to apply P containing fertilizers such as SSP or TSP. The available K content of these soils is within the medium to high ranges with most of them in the high range. The CEC of these soils is in the medium range with very high BS**%**. Sandy clay loam is the major soil type in this village (Figure 20).

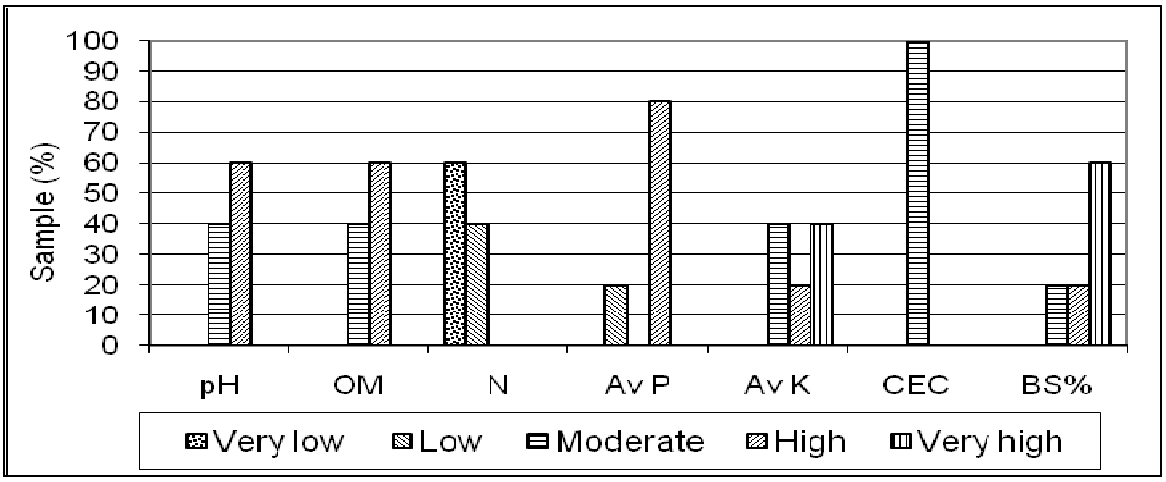


Figure 15 Soil parameters of potato fields in Shadang village.

3.6.8 Soil result of Baging village

The pH and the OM of the soils of this village are within the medium range while the N content is low. The available P is high while the available K is within the medium range. The CEC of these

soils is also within the medium range while the BS% is low. Sandy clay loam is the dominant soil type of this village (Figure 20).

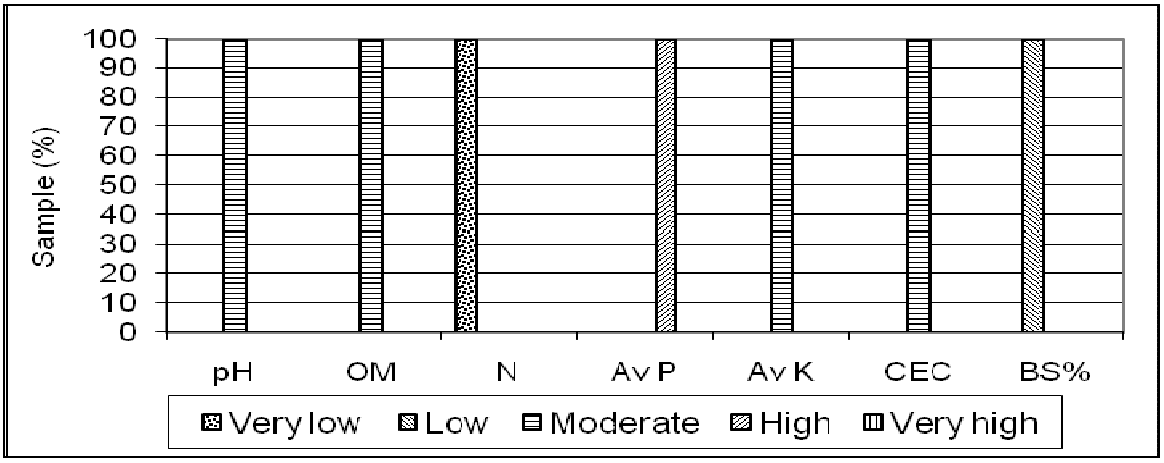


Figure 16 Soil parameters of potato fields in Baging village.

3.6.9 Soil result of Drametse village

The pH of the soils of this village is mostly within the medium range. The organic matter contents of these soils are within the medium to high ranges. The N content is very low. The available P is also mostly within the medium range and about less than 20% each in the low and high ranges The available K is within the medium to high ranges. The CEC is within medium range. Sandy clay loam and sandy loam are the two dominant soil types of this village (Figure 20).

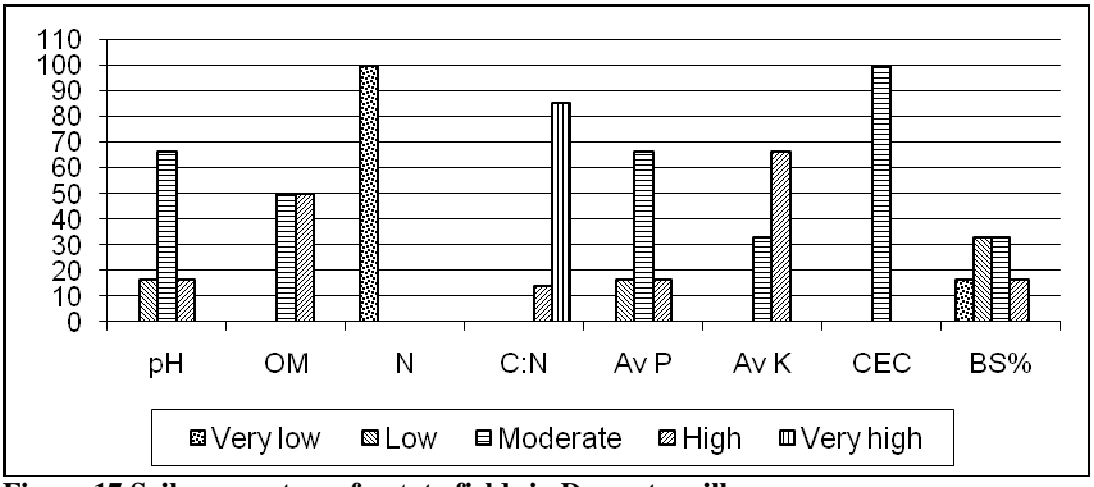


Figure 17 Soil parameters of potato fields in Drametse village.

3.6.10 Soil result of Gope village

The pH of the soils of this village is mostly in the high range while the organic matter content is low to medium ranges. For this village, the ***available P is either very low or low*** and therefore the need to ***apply P containing fertilizers such as SSP or TSP***. The available K is mostly in the medium to high range. The CEC of these soils is mostly within the low to medium range while the BS% is within the medium to very high ranges. Sandy clay and clay loam, moderately fine to fine textured soils are the major soil types of this village (Figure 20).

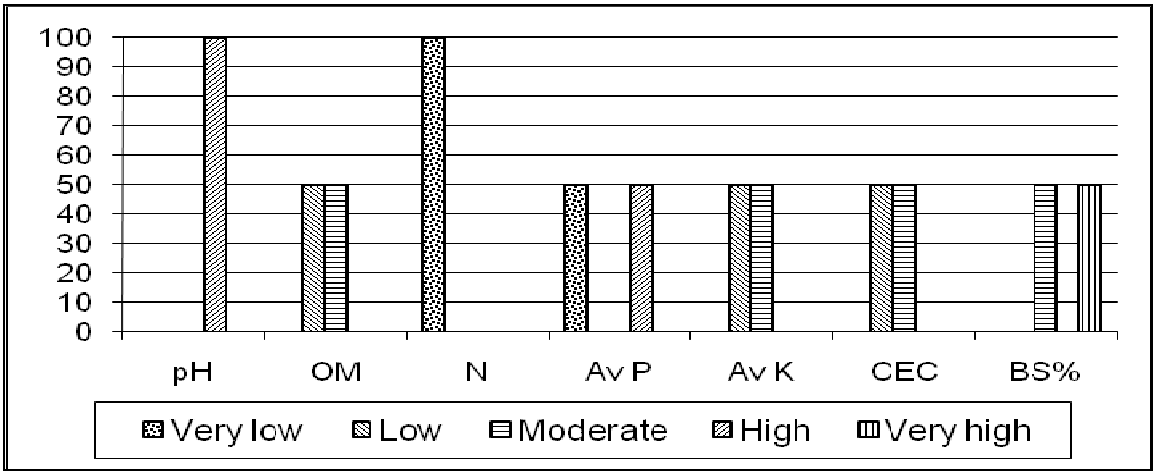


Figure 18 Soil parameters of potato fields in Gope village.

3.6.11 Soil result of Zangkhar village

More than 80% of the soils of this village have high value and only about 15% within the medium range. The organic matter content of these soils is within the medium range. The nitrogrn content is very low for these soils. More than 65% of these soils have ***low P values indicating the need to apply P containing fertilisers such as SSP or TSP*** to improve the P content of these soils and also for good yield. The available K is within the medium range (50% of these samples) while the rest of the samples have high values. The CEC of these soils is mostly within the low to medium ranges and in 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. **Sandy loam (**moderately coarse textured) and **clay loam** (fine textured soils) are the two dominant soil types of this village (Figure 20)

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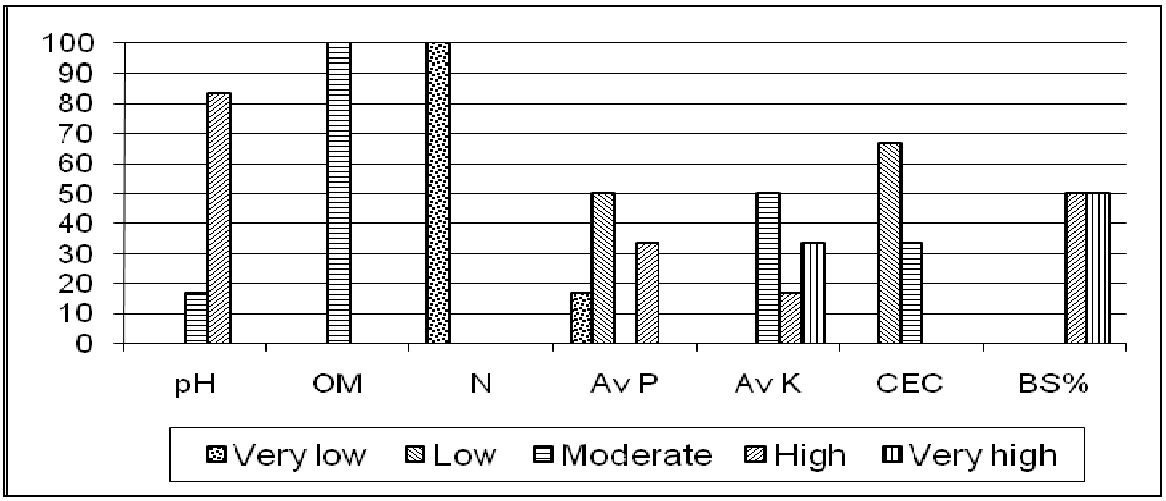

Figure 19 Soil parameters of potato fields in Zangkhar village.

2.6.12 Soil texture of different villages under Drametse geog

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

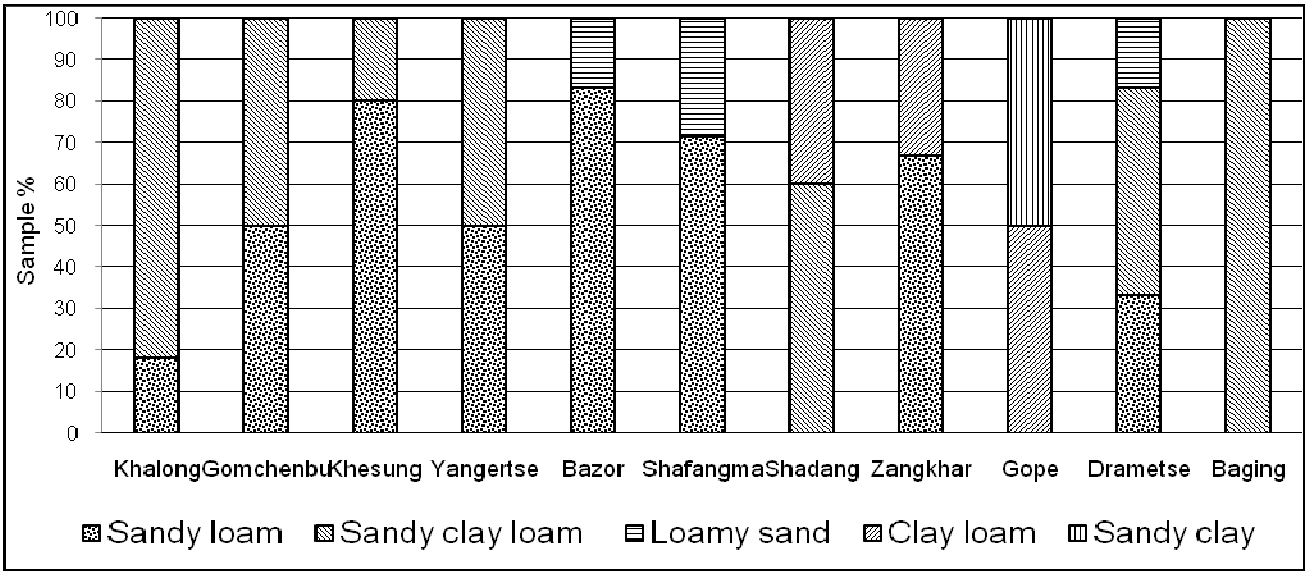

Figure 20 Soil textures of potato fields in different villages under Drametse geog.

4. Conclusions

In Drametse geog the potato is the major cash crop grown while maize planted a month later is mostly used for consumption. The survey findings indicate that more than 50% of the sampled plots are located at medium altitude range of 2000 and 2500 m.asl. The majority of the plots are situated on moderately sloping areas followed by steep slopes and few plots on level and gently sloping areas. The majority of the plots are north-westerly and north-easterly facing aspects. The average field size for potato plantation is less than 1 acre. Desiree is the most preferred potato variety grown by the farmers, which is planted in the month of February.

Almost all the farmers of this village apply FYM and some chemical fertilizers as part of the soil fertility management practices. On an average, the farmers apply about of 11.1 tac^{-1} of FYM to potato and they also apply about 117.3 $kgac^{-1}$ of suphala which is equivalent to 17.6 $kgac^{-1}$ of NPK. No urea is applied to potato though it applied to maize as a top dress.

The average yield of potato and maize is 2.8 tac^{-1} and 2.3 tac^{-1} respectively[e]. Shafangma village reported the highest potato yield of 5.4 tac^{-1} while the highest maize yield of 8 tac^{-1} was recorded from Khalong village. The potato yield figure is lesser than the FAO yield estimate for Bhutan (FAO yield estimate for farmer field is about 6.5 tac^{-1}) indicating the potential for increasing yield with better inputs and management practices. The potato seeds have not been changed for most of the farmers of this geog and only about 42% of the farmers have changed their seed during the last 5 years. This could be one contributing factor for low yield in addition to the low and unbalanced nutrient inputs. However, it was observed that the potato yield increased with increasing rate of fertilizer applications.

[e] These yield figures are less than the figures of 2002 (i.e. potato=3.9tac^{-1}, maize =3.6 tac^{-1}) though no chemical fertilizers were applied in 2002.

On an average, the soil pH of most of the plots is within the suitable range for growing potatoes and maize. The organic matter content of these soils are also within the medium range while the available P and K are within the medium to high range though few villages have very low values. The CEC of these soils in the geog are within the medium range indicating a fairly medium soil fertility status. The major soil types of this geog are sandy clay loam and sandy loam.

5. Recommendations

- The average nutrient input through inorganic fertilizers was 17.55 kgac^{-1} NPK from suphala and 30.82 kgac^{-1} N from Urea. With the limited use of balanced mineral fertilizer, especially P and K, the soil P and K status could deteriorate with time. The farmers of this geog should increase the fertilizer application rates and could include P and K fertilization to get a good yield and also to prevent nutrient mining of their soils.

- For this geog, the soil analytical result indicate a fairly low to medium P and K status The farmers' nutrient application rate of about 48:18:18 kg NPK ac^{-1} is much lower (especially P and K) than the NSSC recommendation of 40:32:32 kg NPK ac^{-1}.

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 3.5) 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 40:32:32 kgac^{-1} of NPK is recommended based on the soil results.

  The P and K values need to be increased for these soils based on the NSSC and FAO recommended rate, as these values from the soil analysis report are low 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 40:32:32 kgac^{-1} of NPK:**

5.1 Using Suphala, urea and MoP (in one acre):

- In order to supply the nutrients at the recommended rates, apply about 213 $kgac^{-1}$ of Suphala as basal dose during land preparation (i.e. about 4 bags of Suphala @50 kg bag^{-1} ac^{-1}).

- Followed by one application of 17 $kgac^{-1}$ of urea once either at the time of flowering of potato or when the maize plants are of knee high stage if intercropped with maize (or two split application of urea @ 8.5 kg each when the plants are knee high and the other at pre tassling stage).

5.2 Using SSP, MoP and Urea (in one acre)[f]:

- Apply 44 $kgac^{-1}$ of Urea as basal dose during land preparation (i.e. about 1 bag of urea @50 kg bag^{-1} ac^{-1}). Followed by urea application as two split top dressings, i.e about 22kg ac^{-1} of urea top dressed when the maize plants are of knee high stage and another 22 kg $ac^{-1}$of urea at pre-tassling stage.

- Apply 200 $kgac^{-1}$ of SSP as basal dose during land preparation (i.e. 4 bags of SSP @ 50 kg bag^{-1} ac^{-1}).

- Apply about 54 $kgac^{-1}$ of MoP as basal dose during land preparation (i.e. about 1 bag of MoP @ 50 kg bag^{-1} ac^{-1}).

- 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.

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

[f] If the farmers are willing, this second type (5.2) of application is more advisable than the first type as the SSP contains additional nutrient (sulphur), which helps in better production of yield.