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## 1. Introduction

Following the first batch of soil samples collected (2002) under potato-maize based farming system from east, a second batch of soil samples were collected from the same fields in December 2008. To generate information on the soil nutrient status as managed by farmers, a database is being built on the soils of the major crops in the country. Soil samples are collected along with the information on farmers' soil fertility management practices, cropping pattern and crop yields from the wetland farming system in Punakha-Wangdi valley, the dryland farming system in Bumthang and Eastern Dzongkhags. Next batch of soil samples will be collected after three years from the same areas.

Trashigang Dzongkhag in the east is one of the major potato-maize growing Dzongkhags followed by Monggar and Pemagatshel Dzongkhags. Though potatoes are grown throughout the Dzongkhag, Khaling geog is one of the most intensively cultivated area other than Kanglung, Yangneer and Thrimshing geogs.

This report is on the soils of the major potato-maize growing areas of the Trashigang Dzongkhag, one of the important potato-maize growing districts. The National Soil Services Centre (NSSC) collected soil samples from about 78 households spread over 14 villages under Khaling 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 78 households were selected from the initial 137 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= 1350$m^2$). 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

This report presents the finding of Khaling geog. The general observations as recorded during the survey are presented in the first part of the report with the average soil analysis result of the whole geo. A soil analysis result of individual village under Khaling geog with fertilizer recommendations based on the findings for each village is presented in the second half.

### *3.1 Sample households*

In Khaling geog, a total of 78 household covering 14 villages[a] were sampled. The highest number of respondents was from Barshon village (19%) followed by Brekha gonpa (12%), Dawzor (9%), Gomchu and Chema with 8% each. Lowest number of respondents with 1% each were from Rashiwung, Panglatong, Dangray and Daewung villages. Only one soil sample (without any management practices) was collected from Daewung as most of the farmers have given up cultivating potato for the last 5-6 years.

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 to have 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 Khaling geog, the majority of the plots (23% of samples) are situated on sloping areas followed by moderately sloping (22% of samples) and about 14% on gently sloping areas. The majority of the plots are south westerly (37% of the plots) and north-westerly (16% of plots) facing aspects. More than 40% 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 60%) of the samples sites have small plot sizes (< or =1 acre). In Khaling, the majority of the farmers (about 38% of the respondents) grow the local variety and only about 8% grow Desiree and few grow both the varieties (Desiree and Yusikarp).

### *3.3 Crop yield and other management practices.*

The farmers assess the fertility of their plots based on 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, potato yield can vary from 16-20 $tac^{-1}$[b] though on an average, the yield is about 7-8 $tac^{-1}$.

The average potato and maize yield of Khaling geog is 3.17 $tac^{-1}$ and 0.95 $tac^{-1}$ respectively. From Figure 1 it can be observed that the maximum potato yield of 13.37 $tac^{-1}$ is reported from Rashiwung village followed by Gonpa (5.94 $tac^{-1}$). The lowest potato yield of 1.56 $tac^{-1}$ is reported from Donphangma. These figures suggest that the potential yield level has not been attained yet and there is the possibility of increasing returns with proper management practices.

The maximum maize yield is reported from Monangkhola (1.48 $tac^{-1}$) followed by Barshon (1.26 $tac^{-1}$) and Dawzor (1.25 $tac^{-1}$) while the lowest maize yield of 0.18 $tac^{-1}$ is reported from Donphangma.

[a] Villages under Khaling geog: Donphangma, Monangkhola, Chema, Rashiwung, Rashiwung toat, Panglatong, Gonpa, Dawzor, Dangray, Khorldung, Daewung, Gomchu, Barshon, Brekha gonpa.

[b] According to FAO reports

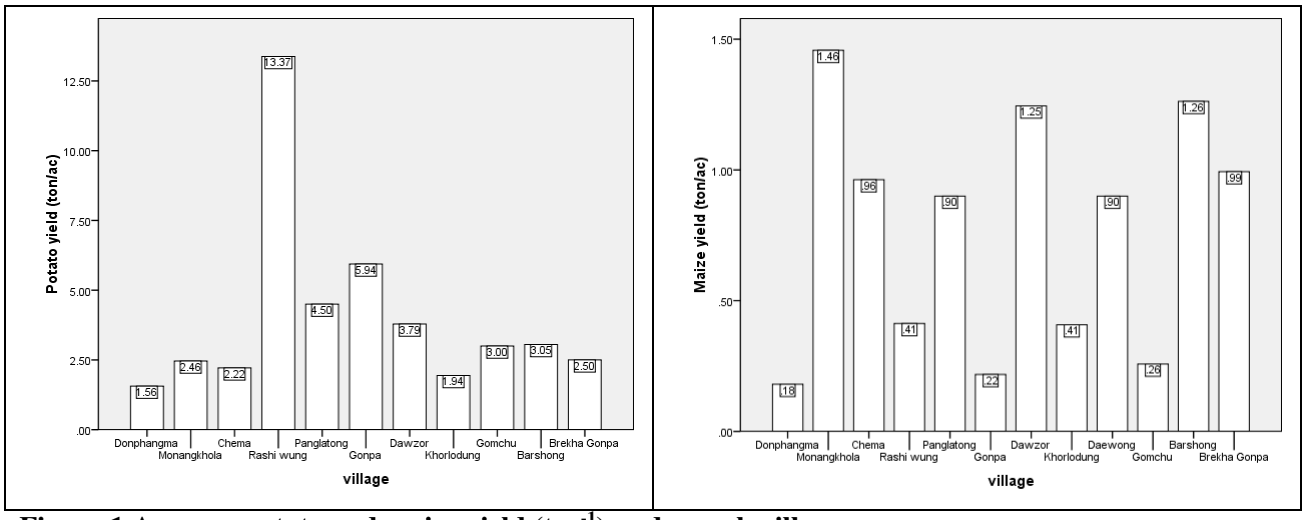


**Figure 1 Average potato and maize yield (tac$^{-1}$) under each village**

In Khaling geog, only about 16% of the farmers have changed the potato seeds while about 43% of them have not changed their seeds and the rest were not sure whether they have changed or not. From this category of farmers who have changed their seeds, only about 14% of them have changed the seeds during the last 5 years. This could be one area to be explored for yield increase in addition to fertilizer inputs and other management aspects.

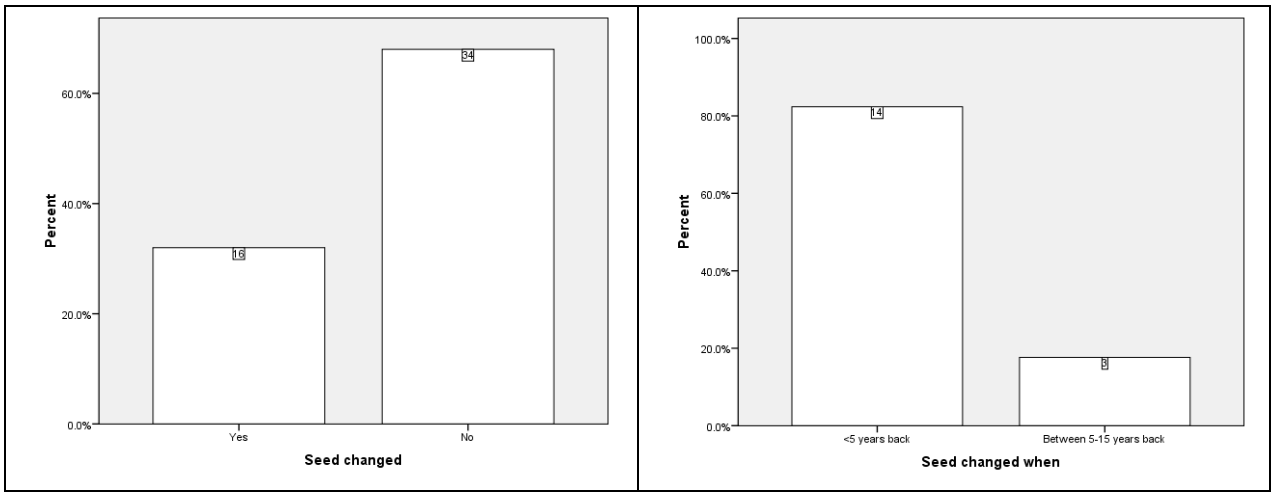


**Figure 2 Potato seeds changed?**

### *3.3.1 Soil fertility management practices*

#### 3.4.1 Farm Yard Manure (FYM)

In Khaling geog, majority of the farmers apply FYM to their fields and few (those without cattle) don't apply FYM. The average FYM application rate is 3.49 tac$^{-1}$ (equivalent to 48.16 kg N ac$^{-1}$, 10.12 kg P ac$^{-1}$, 68.75 kg K ac$^{-1}$ and 82.02 kg Ca ac$^{-1}$)[c]. FYM is usually broadcasted on the fields and incorporated into the soil by ploughing during land preparation. The highest rate of FYM application

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

is recorded from Monangkhola (6.54 $tac^{-1}$), followed by Dawzor (5.5 $tac^{-1}$) and Brekha gonpa (3.76 $tac^{-1}$). Khorldung applies the least FYM to potato (0.9 $tac^{-1}$).

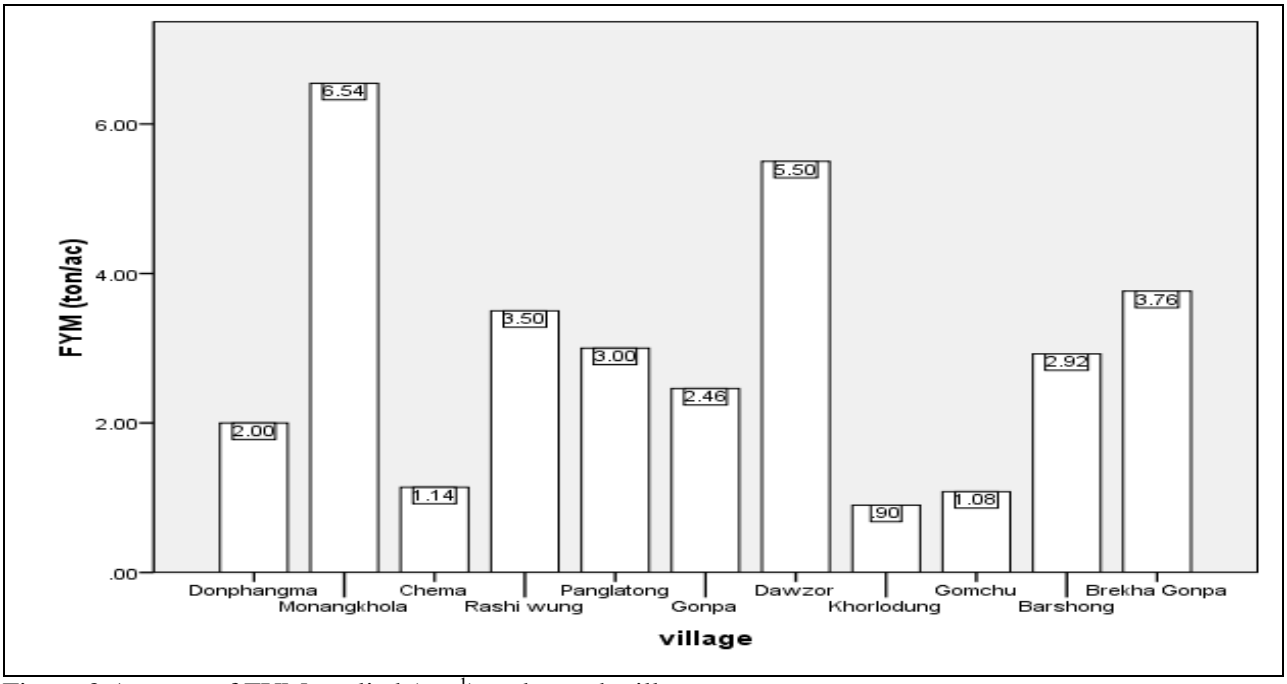


Figure 3 Amount of FYM applied ($tac^{-1}$) under each village.

### 3.4.2 Inorganic fertilizers

The survey findings indicate that almost all the farmers of this geog apply inorganic fertilizers to potato and maize. Suphala and Urea are applied to potato while some urea is also applied to maize as top dress during tassling stage. The average rates of fertilizers applied to potato in this geog are about 129 $kgac^{-1}$ urea and 116.5 $kgac^{-1}$ Suphala. About 108 $kgac^{-1}$ of urea is applied to maize by few farmers. This fertilizer application would amount to about 59 $kgac^{-1}$ N from urea and about 17 $kgac^{-1}$ NPK from suphala. The average nutrient application rate for potato in this geog would be approximately 77:18:18 kg $ac^{-1}$ NPK. Other fertilizers such as SSP and MoP are not applied in this geog and there could be a possibility of exploring fertilizer training program for the farmers of this village on balance fertilizer application and encourage the farmers to apply phosphate and potash containing fertilizers to potato.

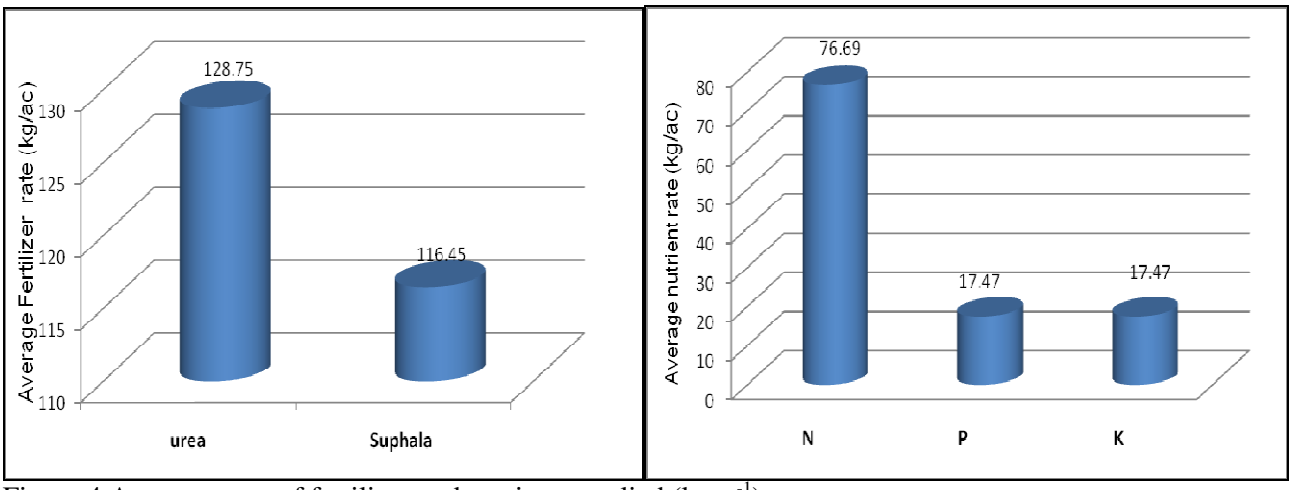


Figure 4 Average rates of fertilizer and nutrients applied (kgac$^{-1}$) to potato.

The highest application of suphala is reported from Donphangma (300 kgac$^{-1}$) and the lowest rate of suphala application is from Khorlung village. Only four villages, viz. Chema, Dawzor, Brekha gonpa and Khorldung applied urea to potato with the highest application rate of 300 kgac$^{-1}$ from Chema village.

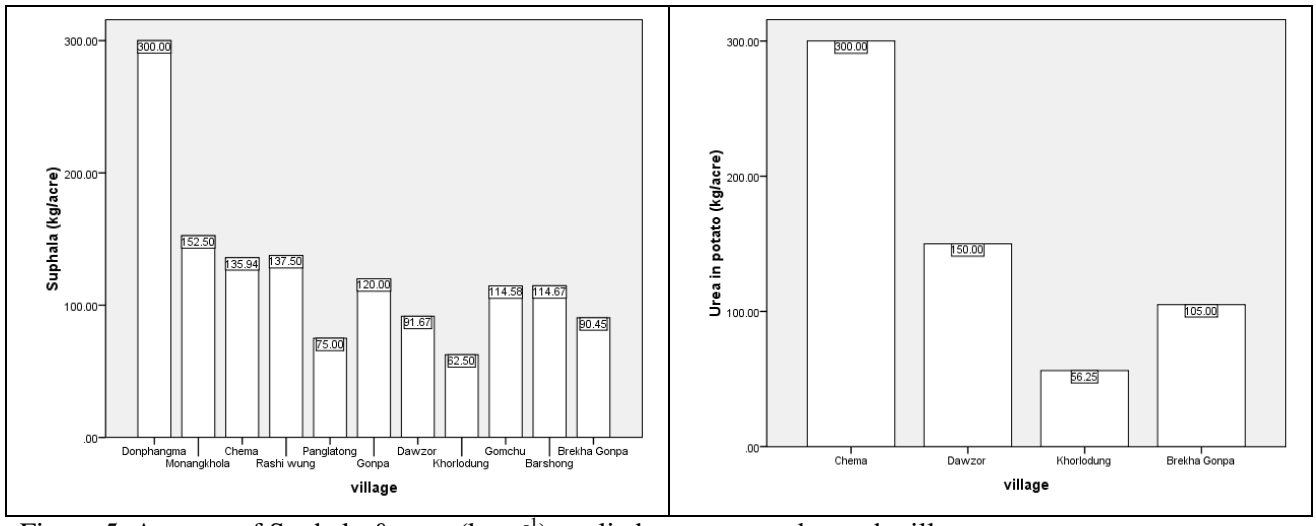


Figure 5. Amount of Suphala & urea (kgac$^{-1}$) applied to potato under each village.

In Khaling geog, 11 villages out of 14 apply urea to maize with the highest application rate from Rashiwung (175 kgac$^{-1}$).

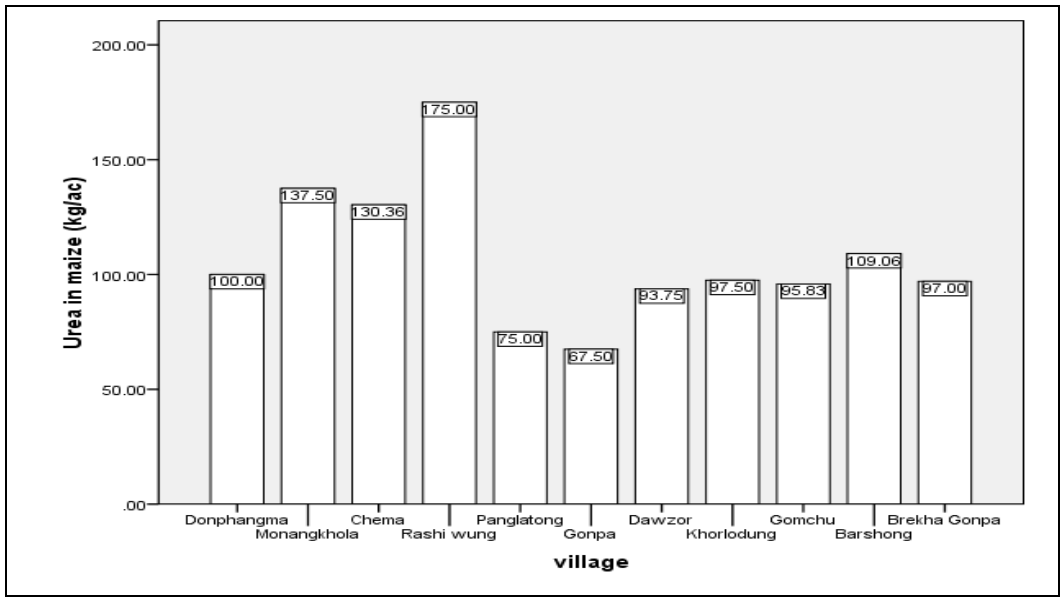


Figure 6. Amount of urea applied to maize ($kgac^{-1}$) under each village

### *3.3.2 Crop yield in relation to inorganic fertilizers application*

From the following figures, it shows that there is no positive yield response with increasing rates of suphala and urea application to potato. The maximum potato yield was about 3.67 $tac^{-1}$ when suphala application rate was between 51- 100 $kgac^{-1}$. However, for maize, there was a positive response of maize yield with urea application rates where the highest yield of 1.8 $tac^{-1}$ was recorded with the urea application rate of 201-300 $kgac^{-1}$.

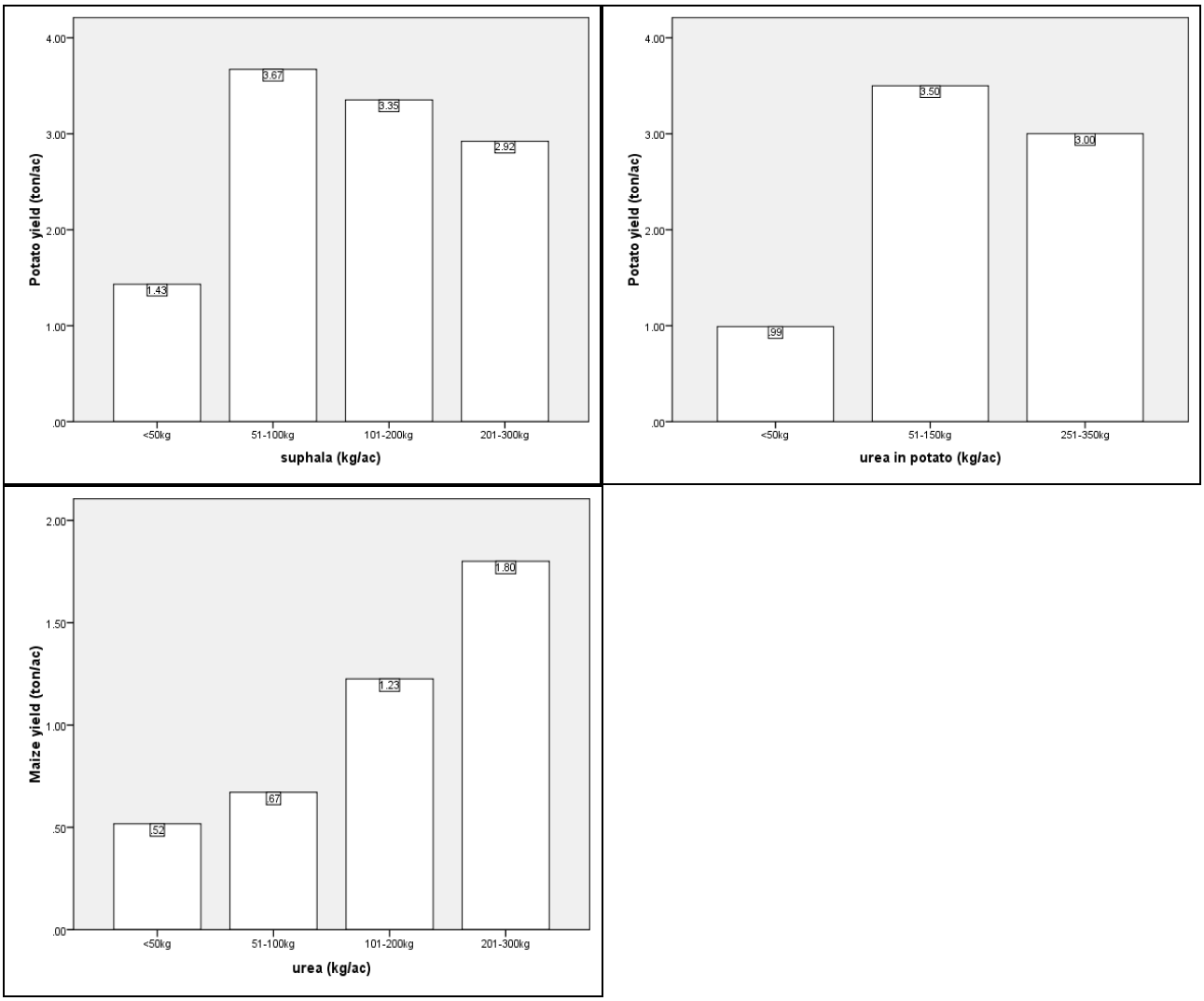


**Figure 7. Potato and maize yield in relation to inorganic fertilizer applied in the geog**

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 Khaling 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 7 shows the soil parameters of the geog. The soil pH is generally categorized into five categories viz. very high (>7.5), high (6.5 to 7.5), medium (5.5 to 6.5), low (5.0 to 5.5) and very low (<5.0).

The majority (more than 46%) of the soils have low pH values and about 40% within the medium range and about 11 % of the farmers have very low soil pH values (details of the farmer list in the individual village report). Potatoes are grown on organic as well as mineral soils. For potato the minimum pH requirement is 5.5 and 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 materials 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 P 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 37% of the samples have low to very low available P while about 17% is within the medium range and about 46% is within the high range. Usually for available P values with low to medium range, there is a possibility of a good yield response with P application. All the soils from Donphangma, Monangkhola, Chema, Panglatong, Gonpa and Brekha gonpa have low P values and therefore the need to apply P containing fertilizers such as SSP or TSP while in the other villages, few selected farmers need to apply P containing fertilizers to their fields (details under individual village report).

### 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 soil if the soil test results show low values.

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

In this geog, about 39% of the samples have high to very high available K and about 46% within the medium and only about 16% within the low range. In general, the K content of these soils is mostly within the medium to high range.

All the farmers of Chema, Dawzor, Dangray; Khorldung, Brekha gonpa (refer Table 1 for name list) have low K values and therefore the need to apply K containing fertilizers such as MoP while in the other villages, few selected farmers need to apply K containing fertilizers to their fields (details under individual village report & Table 1).

### 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 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 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 high to very high ranges, indicating a fairly good soil fertility status thought eh BS% of these soils is mostly within the low range.

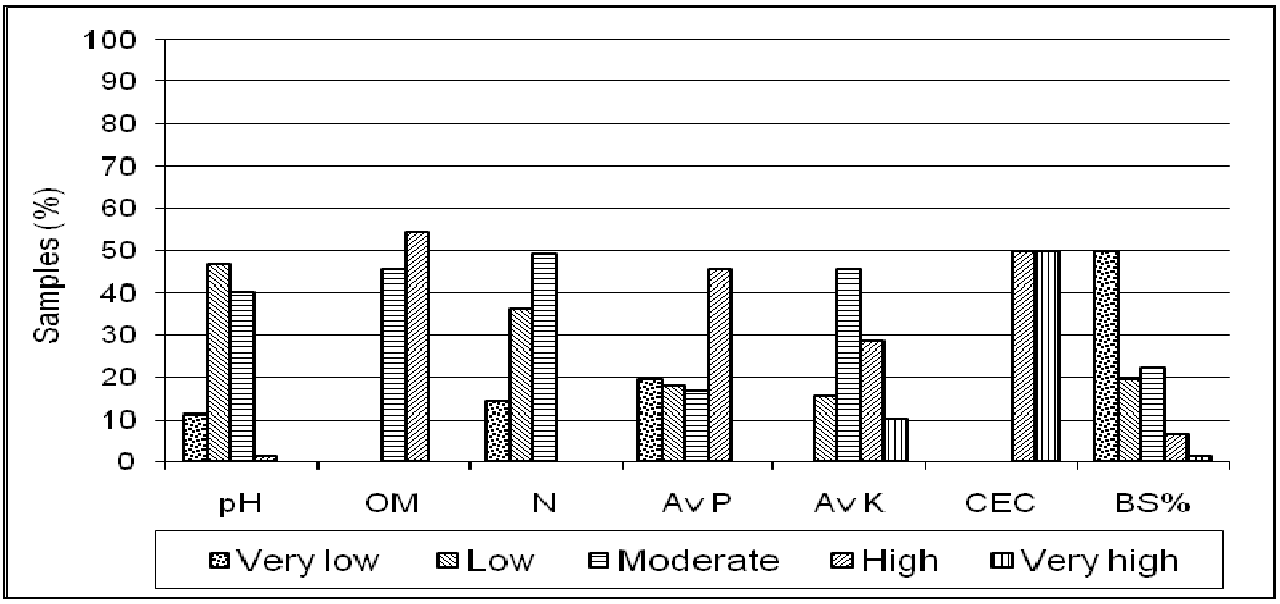


Figure 8. Soil parameters of potato fields under Khaling geog.

### 3.5.7 Soil Texture

Potatoes can be grown in most soil types 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 loam (SL) which is a fine textured soil, Sandy clay loam (SCL) which is a medium textured soil and loam are the dominant soil textures of this geog (28%, 22% and 16% respectively).

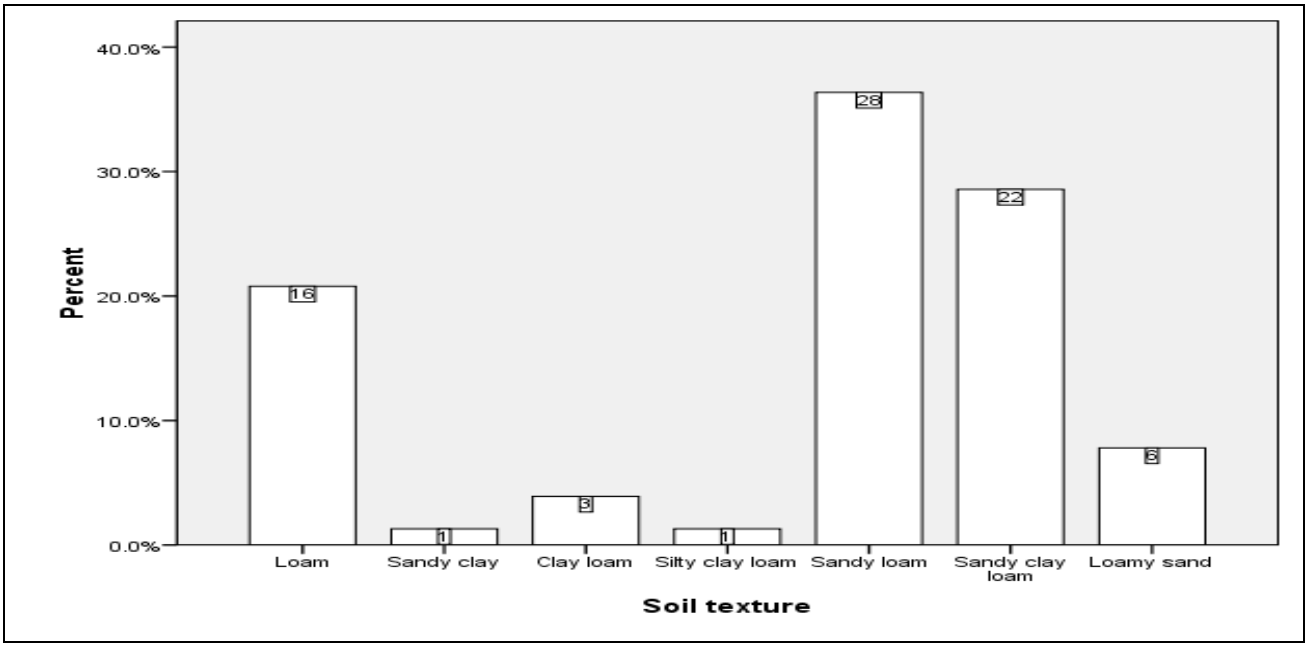

Figure 9 Soil texture of potato fields under Khaling geog (average of all villages)

The soil results of individual village under Khaling geog are summarized as follows.

## *3.6 Soil analytical result of individual village under Khaling geog*

### 3.6.1 Soil result of Donphangma village

The pH of the soils of this village is mostly within the low to medium ranges. The organic matter content of this village is high. The nitrogen content is low. ***The available P content of these soils is low, indicating the need to apply containing fertilizers such as SSP*** (Refer Table 1 for name list). The available K content is high indicating a fairly good K status in the soil. The CEC values are mostly within the high to very high range though the BS% range of these soils is very low.

The major soil type of this village is sandy loam which is a moderately coarse to medium textured soil (containing more than 50% sand with less than 20% clay particles) and loam, a medium textured soil (Figure 22).

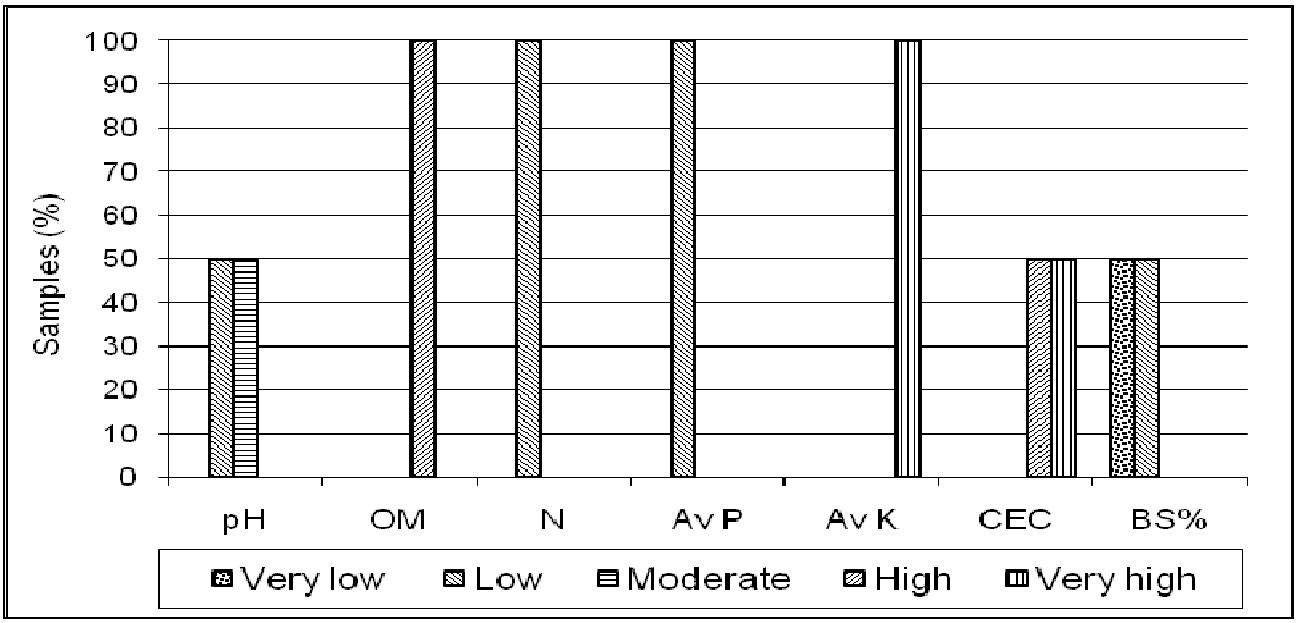


Figure 10 Soil parameters of potato fields in Donphangma village.

### 3.6.2 Soil result of Monangkhola village

The pH of the soils of this village is mostly within the low to medium range which is ideal for growing almost all crops and only one famer with a very low pH range (viz. Ngawang Samten with pH value of 4.89)*. The soil organic matter content is high for this village. The N content is within the medium range. The **available P content of these soils is *very low***. Therefore, to get a good yield, there is a ***need to apply P containing fertilizers such as SSP in this village***. The available K is mostly within the high range and only farmer (Jambay Gyaltshen) with medium values. The CEC of these soils is all in the high ranges which could indicate a fairly good soil fertility status. The base saturation is mostly within the very low to low ranges. Sandy clay loam, a moderately fine textured soil (containing about

35% clay with more than 45% sand particles) and Sandy loam, a moderately coarse to medium textured soil (with less than 20% clay and more than 45% sand particles) are the two types of soils in this village (Figure 22).

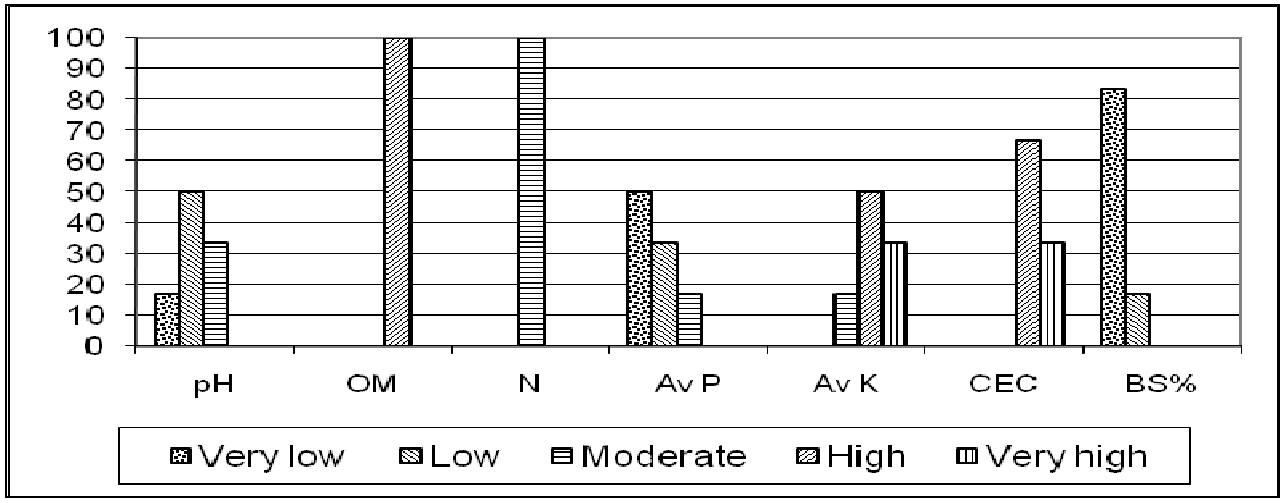


Figure 11 Soil parameters of potato fields in Monangkhola village.

### 3.6.3 Soil result of Chema village

About 60% of these soils are within the low pH ranges and the rest within the medium ranges. The organic matter content of these soils is mostly high. The ***available P of these soils is mostly within the low to very low ranges (about 42%)*** and about 40% within the medium range. These low P values indicate the need to **apply P containing fertilizers such as *SSP or TSP***. The available K content of these soils are mostly within medium ranges (about 71% of these soils) and the rest within the high range. Though the K values are within the medium range, it would be advisable to apply ***K containing fertilizers such as MoP*** to improve the nutrient status of these soils where the values are within the medium range as potatoes are good extractors of K.

The CEC of these soils is mostly within the medium to high range while the BS% range of these soils is within the low range. The major soil types of this village are sandy clay loam, a moderately fine textured soil (containing about 35% clay with more than 45% sand particles) and loam (Figure 21).

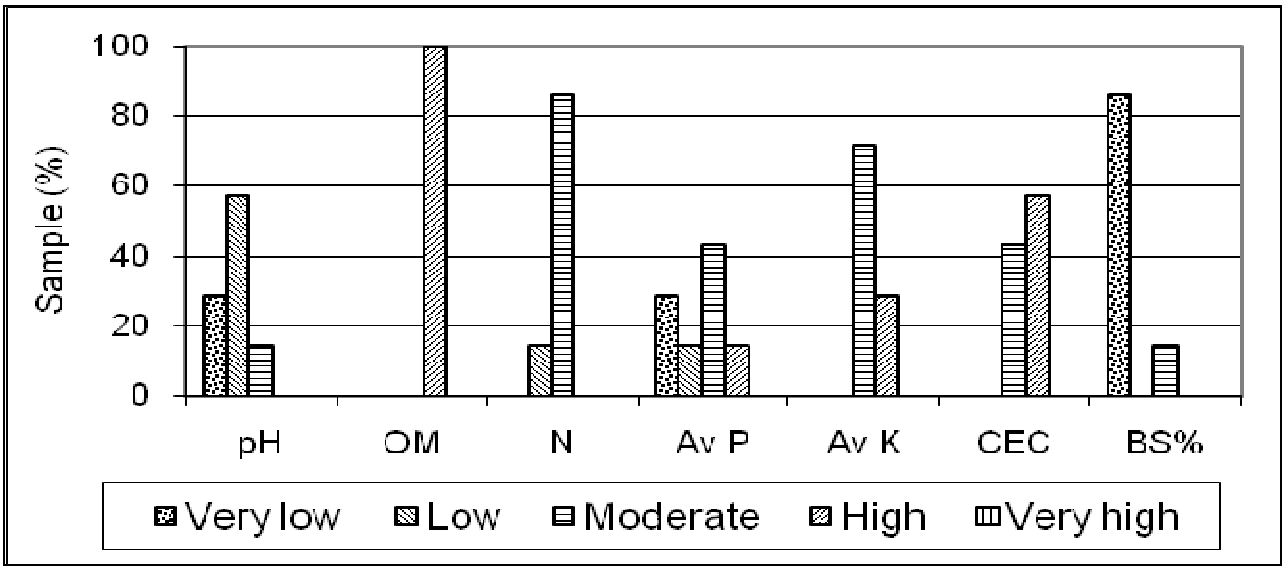


Figure 12 Soil parameters of potato fields in Chema village.

### 3.6.4 Soil result of Rashiwung & Rashiwung toat villages

The pH of the soils of this village is mostly within the low to medium range (75% and 25% of these samples respectively). The organic matter content of these soils is high. The N content of these soils is also within the low to medium range. ***About 50% each of these soils have low*** and high ***P values***. For those with low values, there is the ***need to apply P containing fertilizers such as SSP and TSP***. (refer Table 1 for name list). The available K is also mostly in the medium range (50% of the samples) and high (50% of the samples). Though the K values indicate a fairly good K status, it would be advisable to apply ***K containing fertilizers such as MoP*** for those with moderate values (refer Table 1 for name list).

The CEC of these soils is mostly within the medium to high ranges. The BS% range of these soils is mostly within the very low range. Sandy loam (a moderately coarse textured) and sandy clay loam (moderately fine textured) are the two dominant soil types of this village (Figure 22).

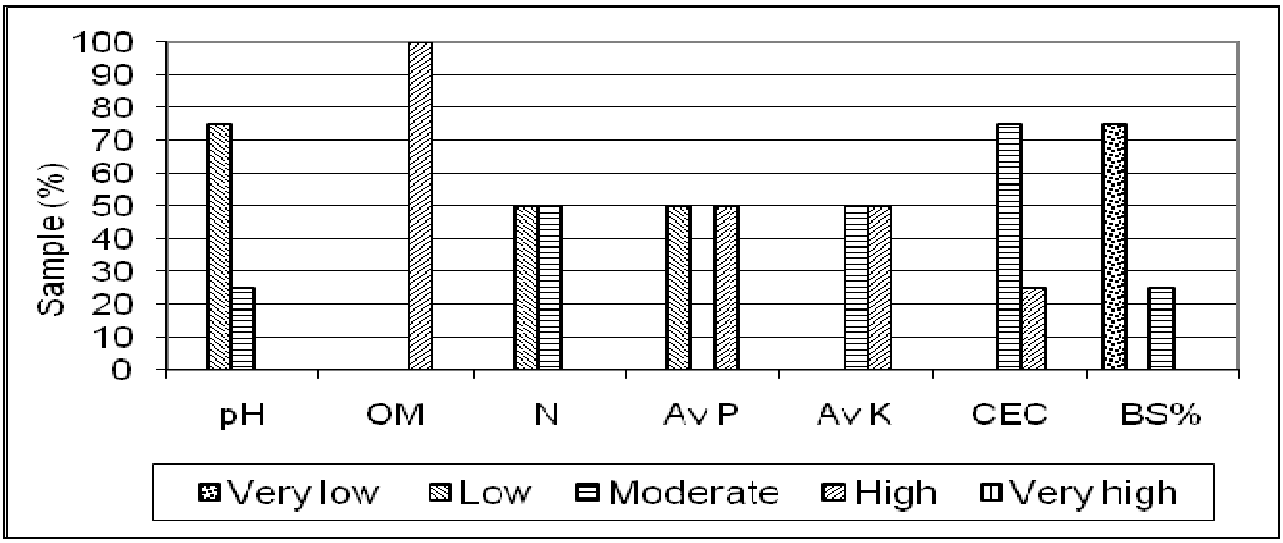

Figure 13 Soil parameters of potato fields in Rashiwung & Rashiwung toat villages.

### 3.6.5 Soil result of Panglatong village

The pH, N and BS% of these soils is low while the organic matter content of the soils in this village is high. The available ***P is very low*** and therefore ***need to apply P containing fertilizers such as SSP or TSP***. The available K is high for this village. The CEC is also high. The major soil type is loamy sand, a coarse textured soil containing more than 70% sand with less than 15% clay particles (Figure 21). For those soils with coarse/light textured soils, a split application of urea (N) is advisable.

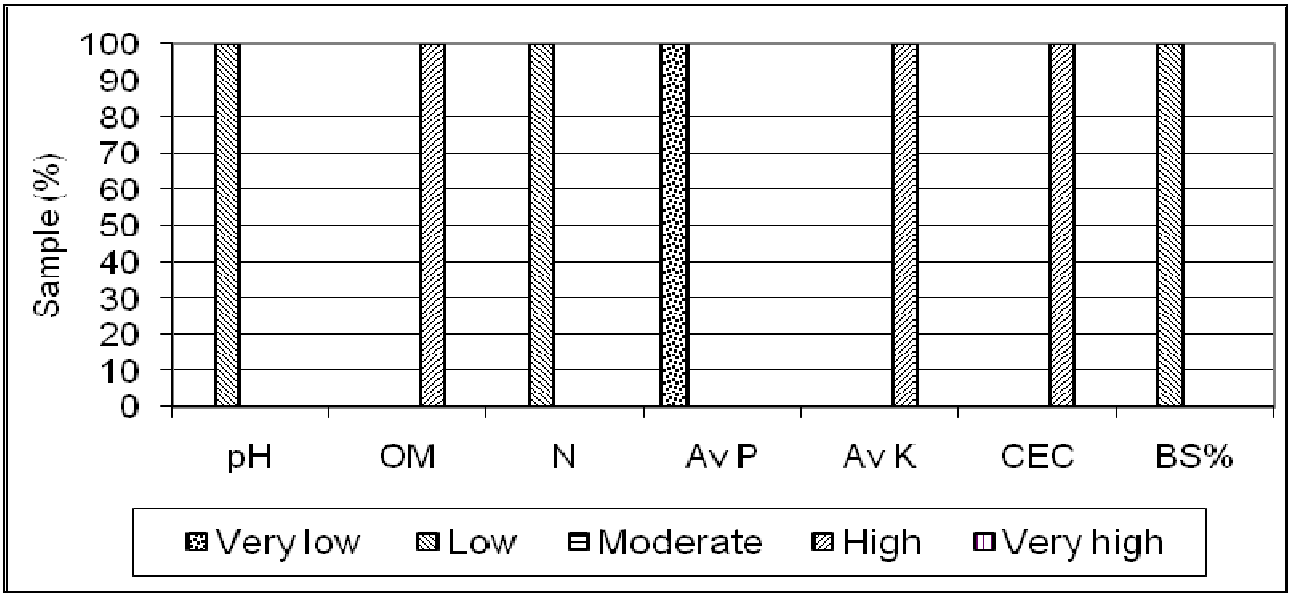


Figure 14 Soil parameters of potato fields in Panglatong village.

### 3.6.6 Soil result of Gonpa village

The pH and the N content of the soils of this village are all within the low to medium range. The organic matter content is within the medium to high range. The ***available P*** is within the ***low*** to medium ranges while about 50% each of these samples ***have low*** and very high ***K values***. For those with low P and K values, there is the need to apply ***P and K containing fertilizers such as SSP and MoP*** respectively. The CEC of these soils is mostly within the low 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 very high. Sandy loam (a moderately coarse to medium textured) and clay loam (moderately fine textured) are the prominent soil types found in this village (Figure 22).

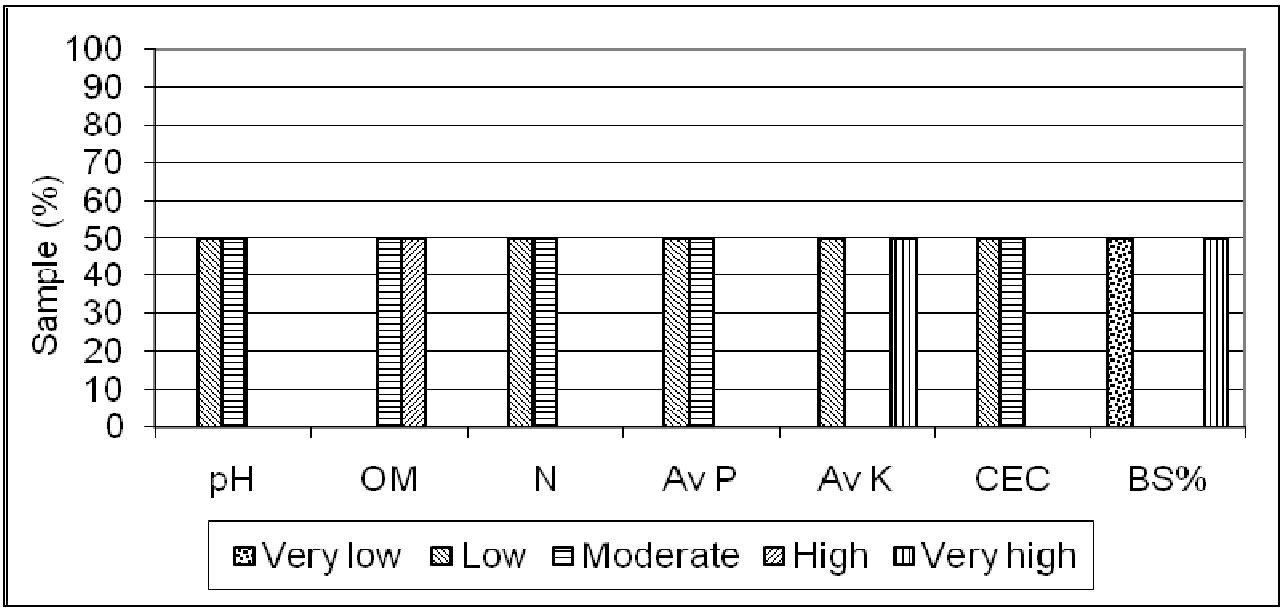


Figure 15 Soil parameters of potato fields in Gonpa village.

### 3.6.7 Soil result of Dawzor village

The pH of the soils of this village is mostly within the low range and few within the very low ranges (Sangay Choden, Jigme & S Choden)* with pH as low as 4.72. For these soils with very low pH values,* another batch of soil samples could be collected from these sites and analysed once again before adding any liming materials. The organic matter content of theses soils is within the medium to high range. The available P of these soils is mostly high except for one farmer with very low P values and therefore the need to apply P containing fertilizer such as SSP/ TSP. The available K content of these soils is distributed within the low to medium to high ranges and therefore ***for those values with low to medium ranges, it is advisable to apply K containing fertilizers such as MoP*** (refer Table 1 for name list). The CEC of these soils is in the low to medium range with BS% distributed from very low to medium ranges**.** Sandy loam and loamy sand are the major soil types in this village (Figure 22).

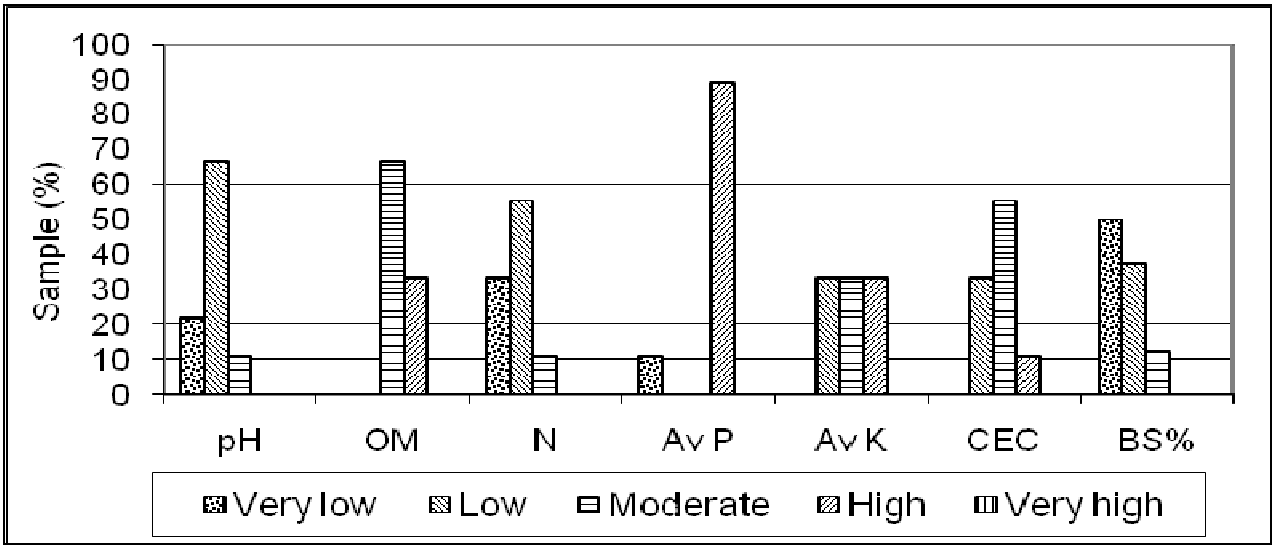

Figure 16 Soil parameters of potato fields in Dawzor village.

### 3.6.8 Soil result of Dangray village

The pH and the N content of the soils of this village is low while the N content is of medium range. The available P is high while the available K is within the medium range. Though the available K is within the medium range, it would be advisable to ***apply K containing fertilizers such as MoP*** for good crop growth and yield. The CEC of these soils is low while the BS% is within the medium range. Sandy loam is the dominant soil type of this village (Figure 22).

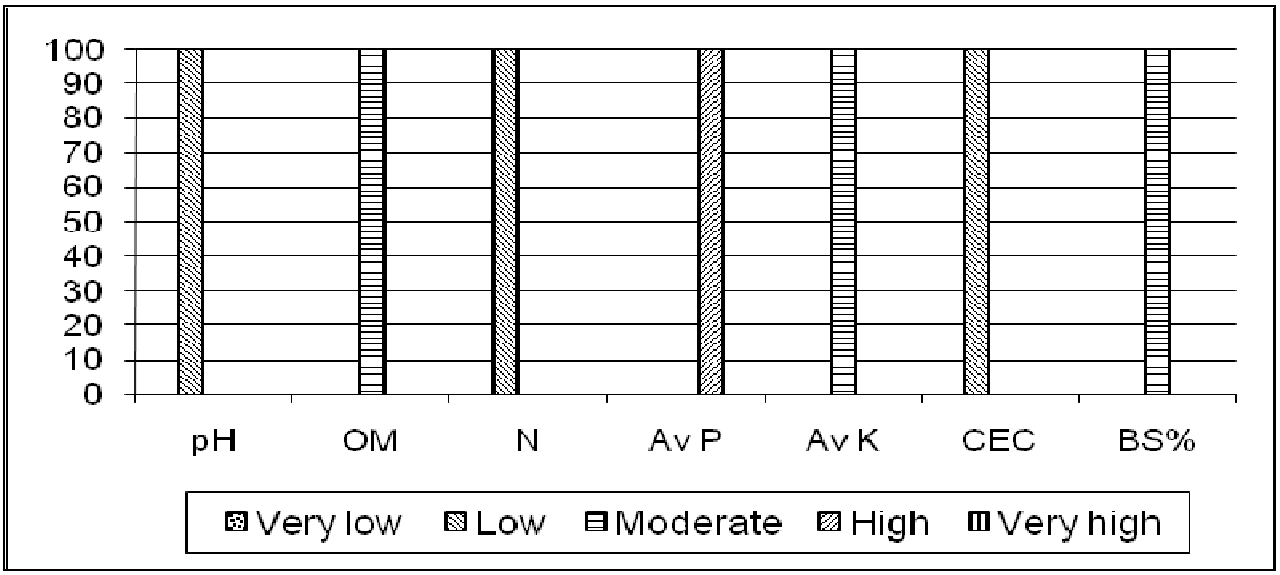


Figure 17 Soil parameters of potato fields in Dangray village.

### 3.6.9 Soil result of Khorldung village

In Khorldung village, most of the soils are within the low to medium pH range except for two farmers (viz. Nima & Am Damcho) with very low pH values (pH of 4.67)*. In such low pH values, growth is impaired and most of the nutrients become unavailable. The organic matter contents of these soils are within the medium to high ranges. The N content is low. The available P is also mostly within the high range and only about 20% in the medium range (refer Table 1 for name list). ***About 80% of the samples have available K within the medium*** range and the rest in the high ranges. Though these values indicate a fairly good K levels, it is advisable to apply ***K containing fertilizers such as MoP***, for those with medium values (refer Table 1 for name list) since K is needed in more quantities by potatoes to do well. The CEC is within low to medium range. Sandy loam is the dominant soil type of this village (Figure 21).

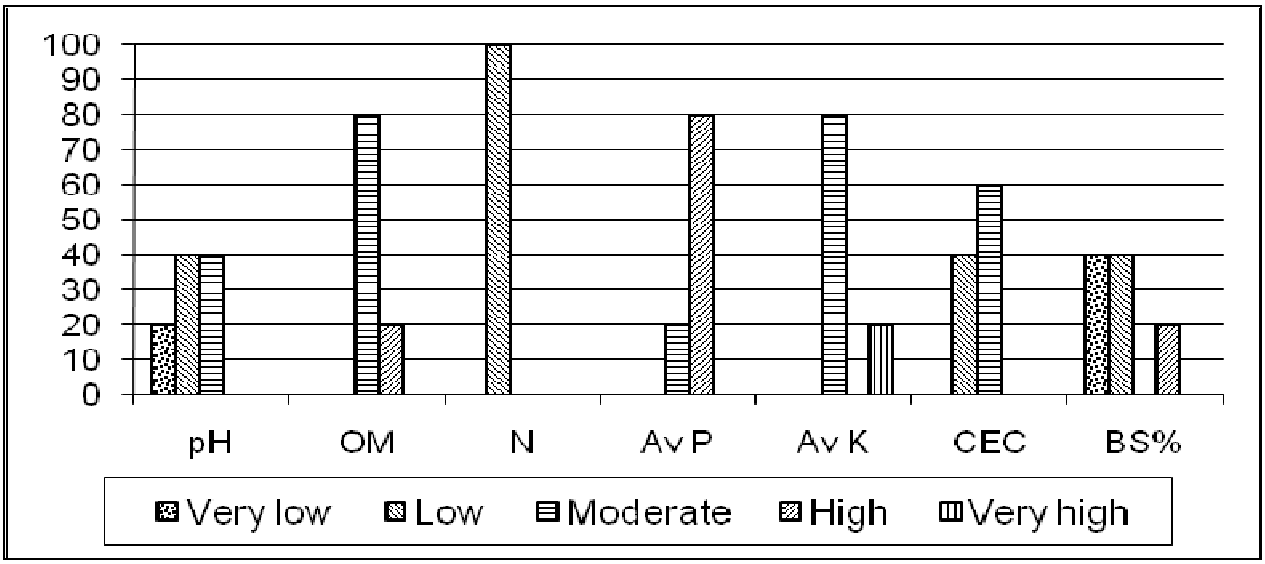


Figure 18 Soil parameters of potato fields in Khorldung village.

### 3.6.10 Soil result of Gomchu village

The pH of the soils of this village is mostly in the medium range (about 50% of thee samples) while about 38% of the soils have low pH values and one farmer (viz Chipon Jamtsho) with a very low pH value (pH of 4.89)*. The organic matter content is low to medium ranges. For this village, the available P is mostly (more than 60% of the samples) within the high range and about 25% within the medium range and the ***rest in the low range*** (refer Table 1 for name list of those with low values) therefore the need to ***apply P containing fertilizers such as SSP or TSP*** for those with low values. The available K is mostly in the medium to high range and only one farmer with low values (refer Table 1 for name list). The CEC of these soils is mostly within the low to medium range while the BS% is distributed from very low to medium ranges. Sandy loam, sandy clay loam, loamy sand and loam are the major soil types of this village (Figure 22).

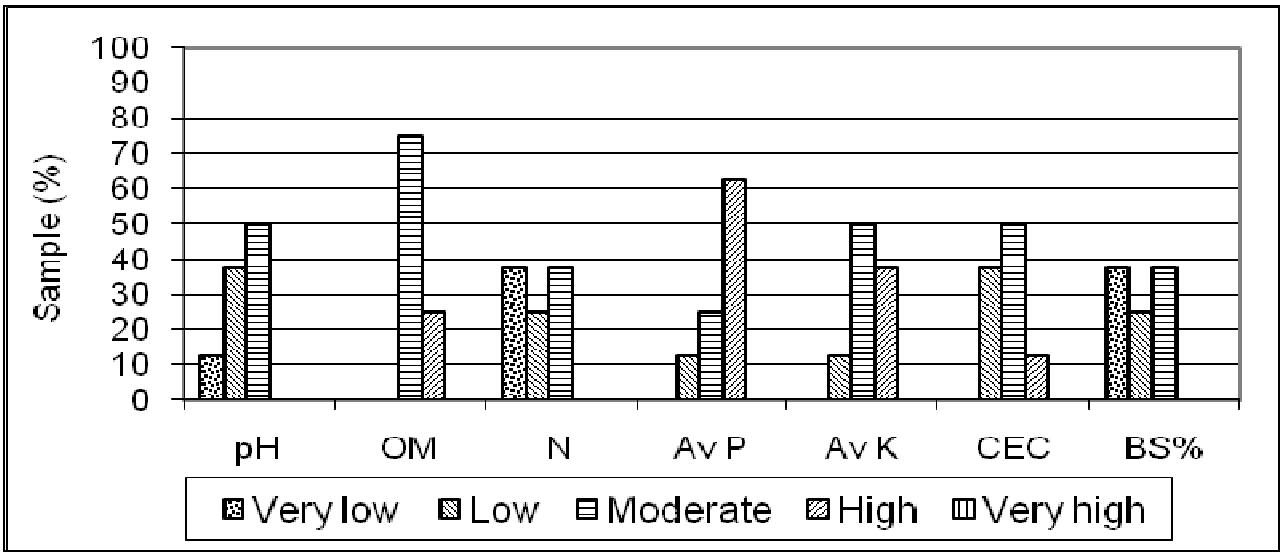


Figure 19 Soil parameters of potato fields in Gomchu village.

### 3.6.11 Soil result of Barshon village

The pH of the soils of this village is mostly within the medium range, ideal for most crops to grow and about 35% of these soils have low pH values and one farmer (Khandu) with very low pH values (pH of 4.85)*. More than 70% of the soils of this village have medium OM range and the rest in the high range. The nitrogen content is mostly in the low range. More than 68% of these soils have high P values and only about ***15% in the low to medium range 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 (refer Table 1 for name list). About 32% of these soils have high to very high K values ***while the rest are within the low to medium ranges*** (refer Table 1 for name list). 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 distributed from very low to very high ranges. Sandy clay loam (moderately fine textured soil) is the major soil type followed by loam and sandy loam (moderately medium textured soils) of this village (Figure 21)

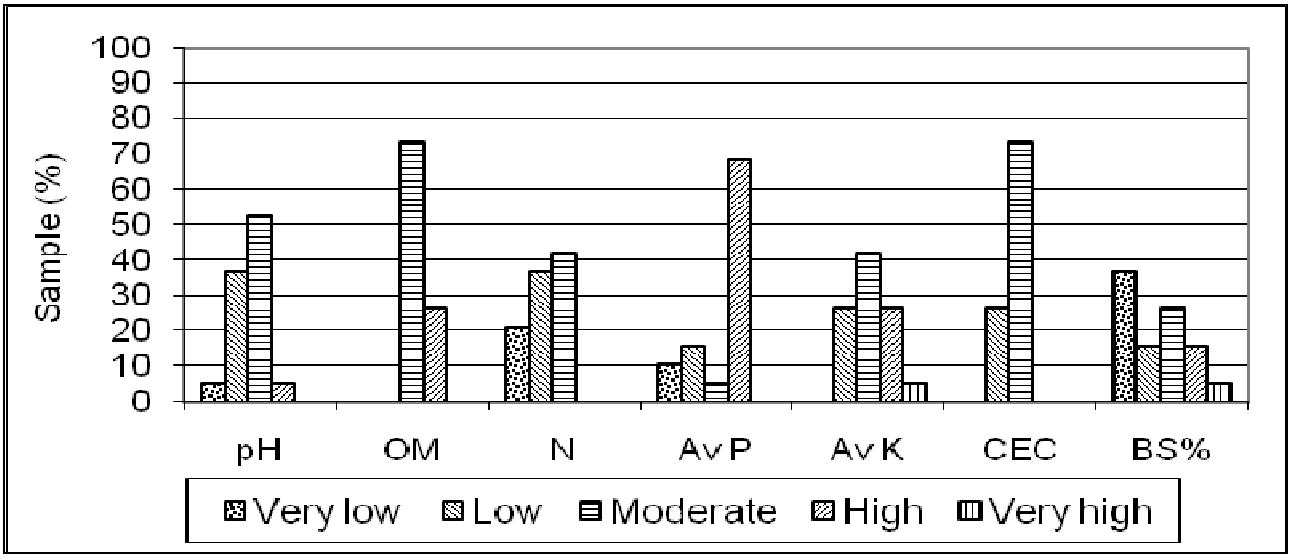


Figure 20 Soil parameters of potato fields in Barshon village.

### 2.6.12 Soil result of Brekha gonpa village

The pH of the soils of this village is mostly within the medium range (about 58% of the samples), ideal for most crops to grow and about 33% of these soils in the low range and only farmer with a very low pH value (viz. Ap Pongko with pH of 4.85)*. More than 83% of the soils of this village have high OM range and the rest in the medium range. The nitrogen content is mostly in the medium range. In Brekha gonpa, more than ***67% of these soils have low to very low available P*** values and therefore the ***need to apply P containing fertilizers such as SSP or TSP***. ***About 17% of these soils have low K values*** (refer Table 1 for name list) and about 58% in the medium range while the rest are in the high range. There is the need ***to apply P containing fertilisers such as SSP & TSP*** to improve the P content of these soils with low to medium ranges. (refer Table 1 for name list). About 32% of these soils have high to very high K values ***while the rest are within the low to medium ranges*** (refer Table 1 for name list) and for those with low to medium ranges, there is the ***need to apply K containing fertilizers such as MoP.***

The CEC of these soils is mostly within the medium to high ranges and very few within the low range. Loam is the major soil type of this village. (Figure 22)

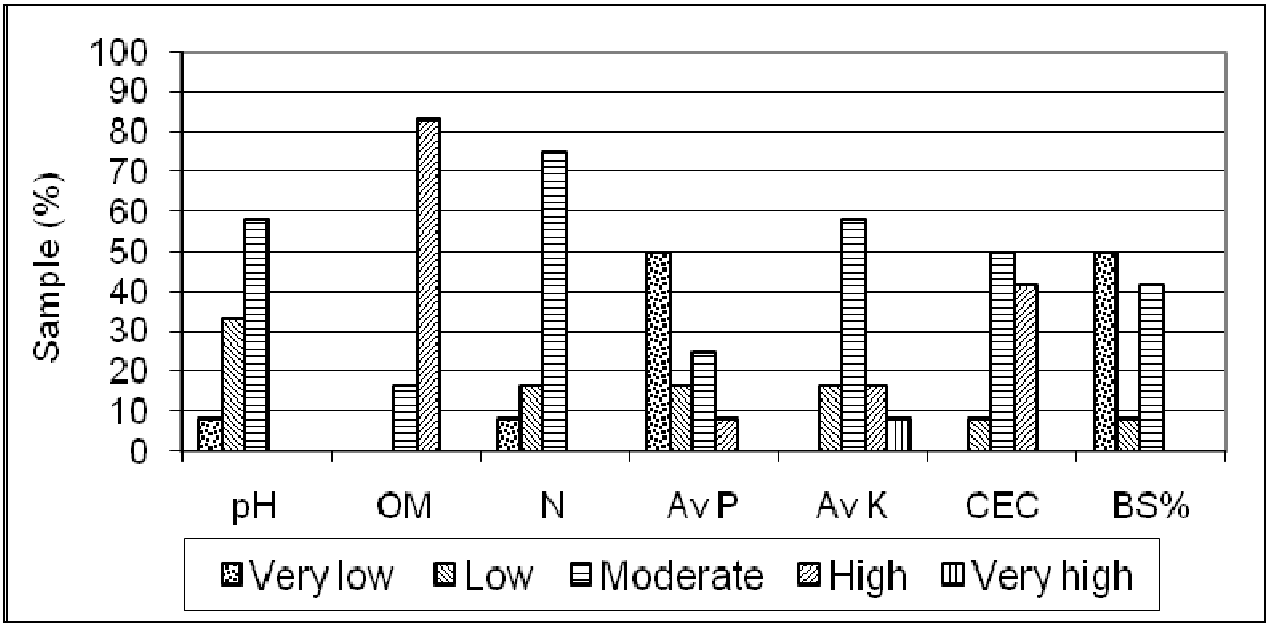


Figure 21 Soil parameters of potato fields in Brekha gonpa village.

### 3.7 Soil texture of different villages under Khaling geog

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

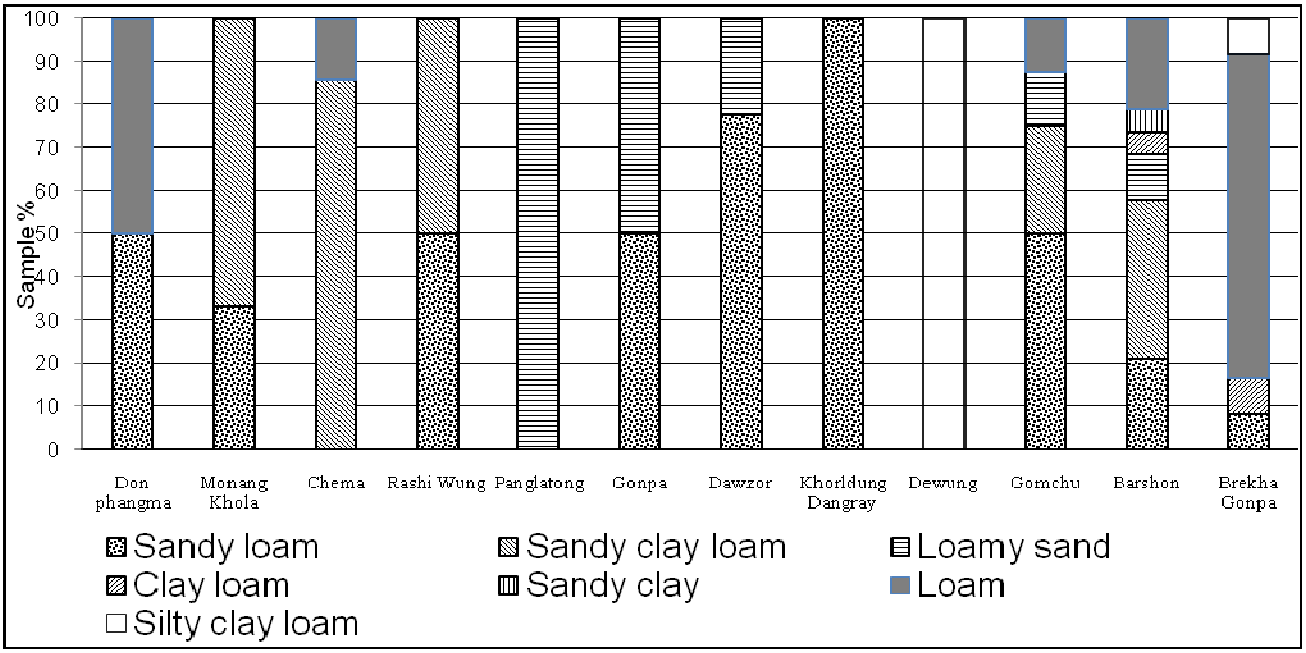


Figure 22 Soil textures of potato fields in different villages under Khaling geog.

## 4. Conclusions

In Khaling geog, 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 40% of the sampled plots are located at medium altitude range of 2000 and 2500 m.asl. The majority of the plots are situated on sloping areas followed by moderately sloping and few plots on gently sloping areas. More than 37% of the plots are south-westerly and north-easterly (about 16%) facing aspects. The average field size for potato plantation is less than 1 acre. The local potato variety is the most preferred potato variety grown by the farmers, followed by Desiree.

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 3.49 $tac^{-1}$ of FYM to potato and they also apply about 116.5 $kgac^{-1}$ of suphala and 129 $kgac^{-1}$ of urea. Urea is also applied to maize by few farmers as a top dress.

The average yield of potato and maize is 3.17 $tac^{-1}$ and 0.95 $tac^{-1}$ respectively[d]. Rashiwung village reported the highest potato yield of 13.37 $tac^{-1}$ while the highest maize yield of 1.48 $tac^{-1}$ was recorded from Monangkhola 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 16% of the farmers have changed their seeds during the last 5 years while few farmers were not sure whether they have changed the seeds or not. This could be one contributing factor for low yield in addition to the low and unbalanced nutrient inputs. However, it was observed that the maize yield increased with increasing rate of fertilizer applications.

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 to high range while the available P is distributed from low to high ranges with about 46% in the high range. The available K is mostly within the medium range though few villages have both low and high values. The CEC of these soils in the geog are within the medium to high range indicating a fairly good soil fertility status. The major soil types of this geog are sandy loam, sandy clay loam and loam.

## 5. Recommendations

- The average nutrient input through inorganic fertilizers was 77 $kgac^{-1}$ N from suphala and urea and 18 $kgac^{-1}$ each of P and K from suphala or 77:18:18 kg $ac^{-1}$ NPK. 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 of P and K to get a good yield and also to prevent nutrient mining of their soils.

- For this geog, the soil analytical result indicate a fairly medium P and K status though individual villages and farmers vary. The farmers' nutrient application rate of about 77:18:18 kg NPK $ac^{-1}$ is much lower (especially P and K) and N is higher than the NSSC recommendation of 40:32:32 kg NPK $ac^{-1}$.

[d] These yield figures are less than the figures of 2002 (i.e. potato= 4.3$tac^{-1}$, maize = 1.12 $tac^{-1}$) also the rate of FYM application is lower than that applied in 2002 (i.e. FYM = 5.3$tac^{-1}$), though there is not much difference in the rates of inorganic fertilizers.

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 the soils in most of the villages where it is low could be improved by applying P containing fertilizer such as SSP together with urea as a basal dose (refer Table 1 for name list).

- The available K content of the soils in those villages with low to medium values, 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 (refer Table 1 for name list).

- 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 and urea. 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 nutriens 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 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) [e]:**

- Apply 44 kgac$^{-1}$ of Urea as basal dose during land preparation (i.e. about 1 bag of urea @50 kg bag $^{-1}$ ac$^{-1}$).

- 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$^{-1}$).

[e] 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.

- 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.

- In addition to this where the major soil type is of medium textured, 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.

* The concerned EA of this geog could collect soil samples from these sites and submit to NSSC for further analysis and rechecking before carrying our any soil corrections.

**Table 1. Name list of farmers of Khaling geog, with low P and K values.**

The following farmers need to follow the above fertilizer recommendations.

| VERY LOW – LOW P | VERY LOW – LOW K |
|---|---|
| SANGAY CHODEN (DAWZOR) | JAMBAY (MONANGKHOLA) |
| AP PEMA (RASHIWUNG) | DUBA (RASHIWUNG & RASHIWUNG TOAT) |
| LHUNDRUP & PEMA WANGMO (RASHIWUNG TOAT) | KINZANG WANGMO (RASHIWUNG & RASHIWUNG TOAT) |
| YESHI DORJI (KHORLDUNG) | LOPEN UGYEN (GONPA) |
| LHADON (GOMCHU) | KEZANG DORJI (GOMCHU) |
| TANDIN TSHOMO (GOMCHU) | TANDIN TSHOMO (GOMCHU |
| LHAZOM (BARSHON) | CHIPON JAMTSHO (GOMCHU) |
| CHODEN (BARSHON) | LHADON (GOMCHU |
| THINLEY + KEZANG (BARSHON) | KHANDU (BARSHON) |
| NAMTAY WANGDI (BARSHON) | ZANGMO (BARSHON) |
| LHADON (BARSHON) | THINLEY + KEZANG (BARSHON) |
| | NAMTAY WANGDI (BARSHON) |
| | LUNGTEN + PEMA CHODEN (BARSHON) |
| | LUNGTEN JAMTSHO (BARSHON) |
| | RINCHEN & YESHI WANGMO (BARSHON) |
| | WANGCHUK (BARSHON) |
| | LHADON (BARSHON) |
| ALL THE FARMERS OF<br>• DONPHANGMA<br>• MONANGKHOLA<br>• CHEMA (EXCEPT TSONGPA)<br>• PANGLATONG<br>• GONPA<br>• BREKHA GONPA (EXCEPT PEMA GYELTSHEN). | ALL THE FARMERS OF:<br>• CHEMA (EXCEPT PEMA WANGDI , LANGA, TENDREL)<br>• DAWZOR (EXCEPT CHENING DORJI, MRS. TSHERING, YESHI DORJI)<br>• DANGRAY<br>• KHORLDUNG (EXCEPT NIMA & AM DAMCHO)<br>• BREKHA GONPA (EXCEPT NGAWANG TENZIN, CHETEN TSHERING, KARCHUNG). |