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1. Introduction

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

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

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

2. Method

As the Extension Agent (EA) was busy with the surveyors surveying land at the time of the visit, the group collected the soil samples from the farmers' fields with the help of the village Chipons. 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 Yangneer geog

3.1.1 Total sample households

In Yangneer geog, a total of 54 households covering 14 villages were sampled. The highest number of respondents was from Changzee (19%) followed by Gongthung gonpa and Gongthung shokha (17% and 13% respectively). Darjeling, Gongthung tektekpa and Gongthung braga had the lowest number of respondents (2% each). These figures show that there are more farmers growing potatoes in Changzee, Gongthung gonpa and Gongthung shokha compared to Darjeling and Gongthung tektekpa and Gongthung braga villages. The various management practices and other site parameters in addition to the soil results are presented below.

3.1.2 Site description:

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

In Yangneer geog, about 70% 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 (62%) of this geog are situated on steep slopes and few plots about 19% are located on moderately sloping. The majority of the plots are either east or north-easterly facing aspects (48% and 37% respectively) and 100% 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. About 84% of the farmers plant their potatoes in February while few households plant either in January and March (8% each). Desiree, a red variety is the most preferred potato variety of this geog (95%) as it fetches better price than the white variety. About 73% of the farmers start planting potatoes in February though few farmers plant as early as January and as late as March. All the farmers of this geog have small land area under potato (100%).

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 moderately sloping, sloping and steep areas and from east, south and northeast facing areas. The majority of the plots are located in the steep and moderately sloping areas with east and northeast facing aspects.

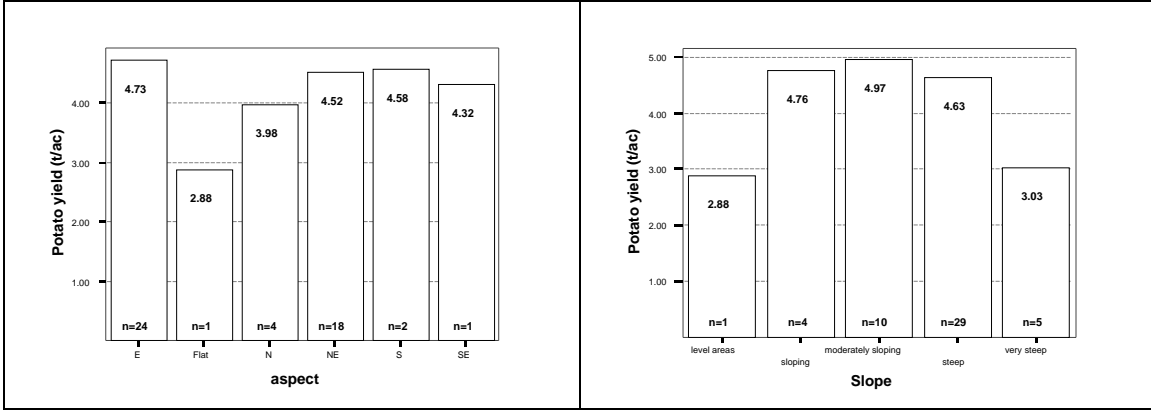


Figure 1 Potato yield in relation to aspect and slope of the plots.

As in any other village or geog in the east, potato is usually intercropped with maize. Maize is 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 potato yield is recorded from one farmer in Gongthung tektekpa (10.5t/ac) followed by Baynang (5.7t/ac) and Changzee (5.6t/ac) villages while Minduling, Tashiling (2.7t/ac each) and Gongthung Braga (2.9t/ac) reported the least yield though the average potato yield for Yangneer geog is 4.5t/ac. The highest maize yield is recorded from Waiphung (6.9t/ac) followed by Gongthung tektekpa and Gongthung braga (4.5t/ac each) villages while the lowest yield is reported from Darjeling (1.2t/ac), Tashiling (1.3t/ac) and Minduling and Gongthung gonpa with 1.8t/ac each (see figure 2). On an average, the maize yield for this geog is 2.9t/ac.

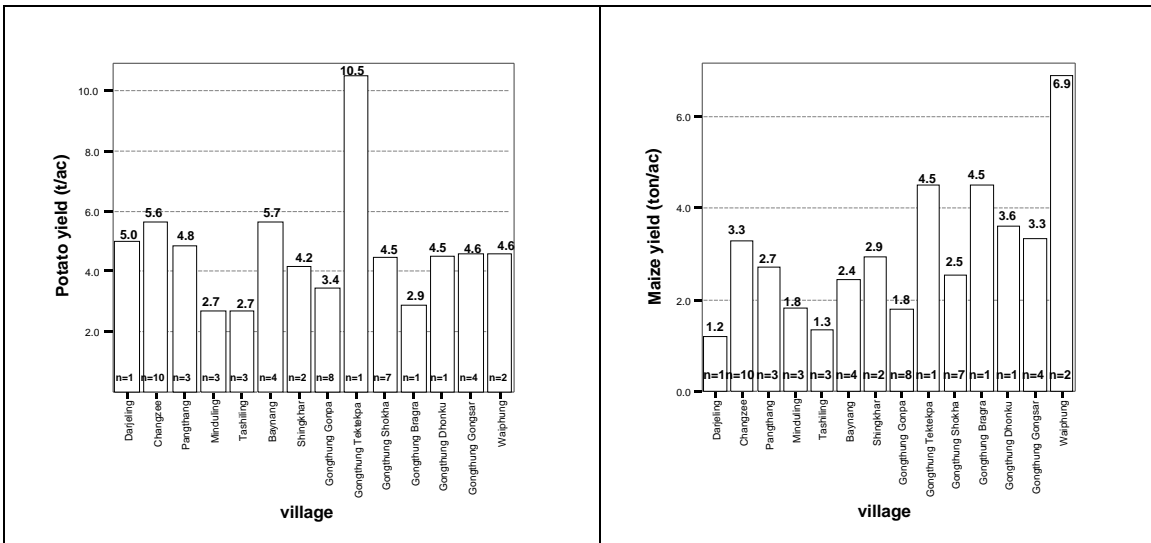


Figure 2 Average potato and maize yield (t/acre) under each village.

¹ According to FAO reports.

In Yangneer geog, all the farmers apply Farm Yard Manure (FYM) to their fields with an average application of 12t/ac. This amount of FYM applied with a dry matter content of 50% is equivalent to 6t/ac. As in elsewhere, FYM is usually broadcasted in the fields and incorporated into the soil by ploughing during land preparation. The highest rate of FYM application (t/ac) is one farmer from Gonghtung tektekpa village (31.5t/ac) followed by Gongthung dongku (27t/ac) and Gongthung braga (22.5t/ac) villages while Baynang (5.6t/ac), Gongthung gongsar (6.8t/ac) and Pangthang (7.3t/ac) villages applied the least amount of FYM (figure 3). The majority (92%) of the farmers of this geog do not practice tethering of cattle in the fields while all the farmers (100%) burn their trash after crop harvest prior to land preparation. The weeding frequency of the potato ranges from once to more than thrice though about 53% of them weed thrice and another 39% of the farmers weed only twice and few farmers (6%) even weed more than three times.

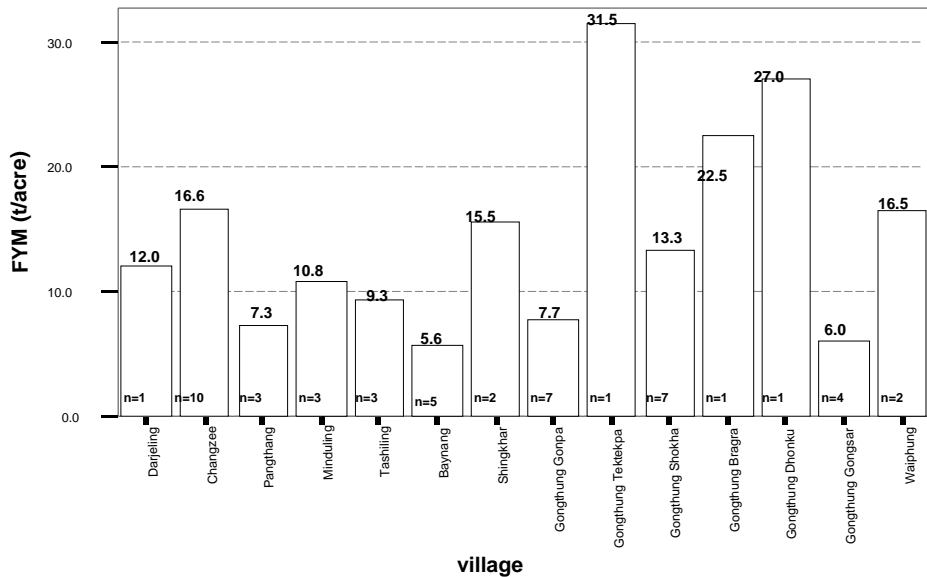


Figure 3 Amount of FYM applied (t/acre) under each village.

The survey findings indicate that about 98% of the farmers apply inorganic fertilizers such as suphala, urea and SSP in addition to FYM application though the majority of the farmers apply more suphala in comparison to urea and SSP. About 61% of the farmers of this geog apply Supahala to potato (basal dose) while only about 37% of them apply urea as basal in potato and about 18% of them apply SSP to potato. About 92% of the farmers apply urea to maize. The average amount of suphala applied by the farmers of Gongthung gongsar vilage (225kg/ac) is more than the rest of the other villages while Tashiling (50kg/ac) applied the least (Figure 4). On an average, the farmers of this geog apply about 135kg/ac suphala, which is 20.3kg N per acre, 20.3kg P per acre and 20.3kg K per acre. About 135kg/ac urea (which is 66kg N per acre) is applied by 37% of the farmers as basal dose, which is either applied singly or is mixed with SSP in

the ratio of 1:2 (urea: SSP). About 18% of the farmers also apply on an average 104kg/ac SSP (which is about 17kg P per acre) as basal dose to potato. The basal fertilizer is applied in a band while urea top dress, broadcasted near the plants is mostly applied in a single dose. Almost all the farmers (98%) apply urea in a single dose either when the maize is of “knee high stage” of growth or at “pre-tasselling stage”.

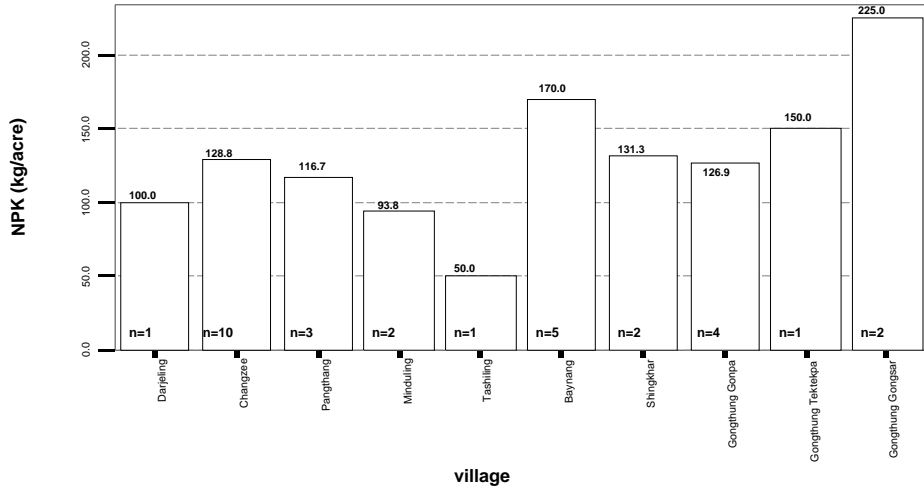


Figure 4 Amount of Suphala (kg/acre) applied under each village.

From the following figure 5, it can be seen that on an average the highest amount of urea application to potato is from Waiphung village (175kg/ac) followed by Darjeling and Gongthung tektekpa (150kg/ac each) villages while the farmers of Changzee and Tashiling (23kg/ac and 25kg/ac respectively)) applied the least amount of urea to potato. The farmers of Pangthang, Minduling, Baynang, Shinangkhar, Gongthung braga and Gongthung dhonku do not apply urea to potato.

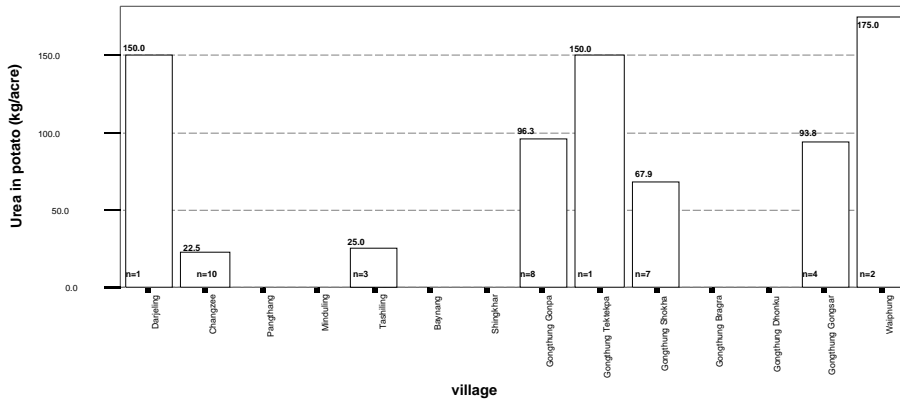


Figure 5 Amount of Urea (kg/acre) applied to potato under each village.

As reported earlier, only about 18% of the farmers of this geog apply SSP as basal to potato in combination with urea. On an average, the highest application of SSP as basal dose is one farmer from Darjeling (100kg/ac) followed by Changzee village (45 kg/ac) while the farmers of Shingkhar and Gongthung gonpa applied the least. Farmers of Minduling, Tashiling, Baynang, Gongthung tektekpa, Gongthung shokha, Gongthung braga, Gongthung dhonku, Gongthung gongsar and Waiphug do not apply SSP at all. See figure 6.

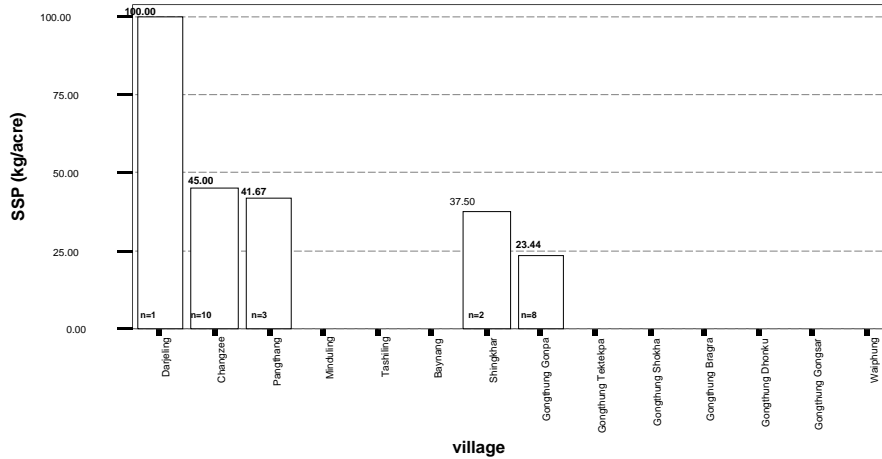


Figure 6 Amount of SSP (kg/acre) applied in potato under each village.

In addition, about 92% of the farmers also apply on an average 148kg/acre of urea (i.e. about 70kg N per acre) as top dress to maize. The highest amount of urea application as top dress in maize is reported from one farmer of Gongthung braga village (225kg/ac) followed by Gongthung gongsar (212kg/ac) and Gongthung shoka (187kg/ac). Waiphug (75kg/ac) and Minduling (83kg/ac) villages applied the least amount. See figure 7.

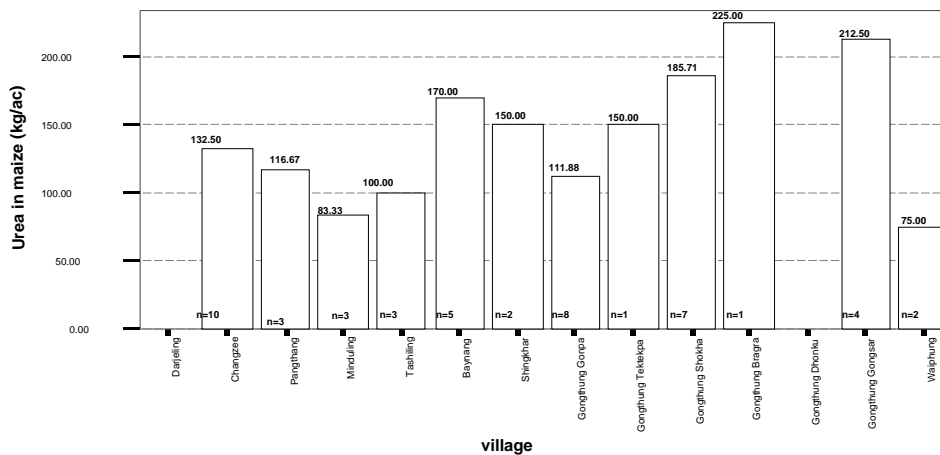


Figure 7 Amount of Urea (kg/acre) applied in maize under each village.

3.1.4 Soil results of Yangneer geog.

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

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

i. Soil result of Darjeling village (see figure 8).

The pH of the soils of this village is 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 of this village is of medium range (100-200mg/kg) while the available P is low (5-15mg/kg). There fore, the need to apply P and K containing fertilizers to improve the nutrient status of these soils. The organic matter of these soils is of medium range with very high C:N ratio. The CEC of these soils is low (5-15 me/100g) while the BS% is very high (>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 sandy loam (figure 18). This soil type is of medium textured soil containing less than 40% clay content. However, for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

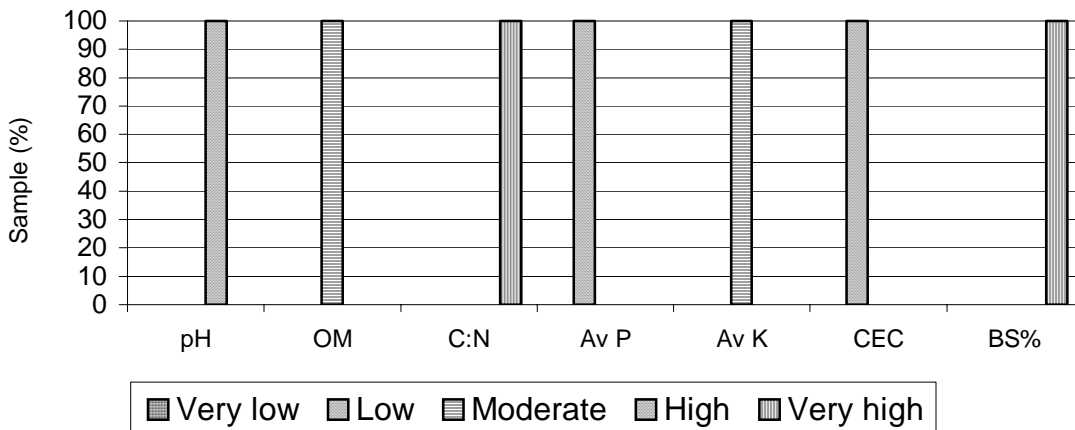


Figure 8 Soil parameters of potato fields in Darjeling village.

ii. Soil result of Changzee village (see figure 9).

The pH of the soils of this village is mostly within medium (pH 5.5-6.5) to high range (6.5-7.5) range. The available K is mostly (about 70% of these soils) is within the moderate range (100-200mg/kg) while another 20% are within the low range (40-100mg/kg). The available P of these soils is mostly of low range with 60% in the low and another 30% in the very low range. These figures suggest that the available P and K content of these soils are within the low to moderate range respectively. However, it would be advisable to **apply P and K containing** fertilizers to improve the soil nutrient status. The organic matter content of these soils is within the low to medium range with very high C:N ratio (>12). The CEC values of these soils are low while the BS% is high. In such low CEC soils, all major macro and micronutrients are needed to obtain good crop growth and yield. The major soil types of this village are sandy clay loam and clay loam (figure 18). These soil types are of medium textured soils containing less than 40% clay content and for light textured soils, a split application of inorganic fertilizers especially urea is advisable.

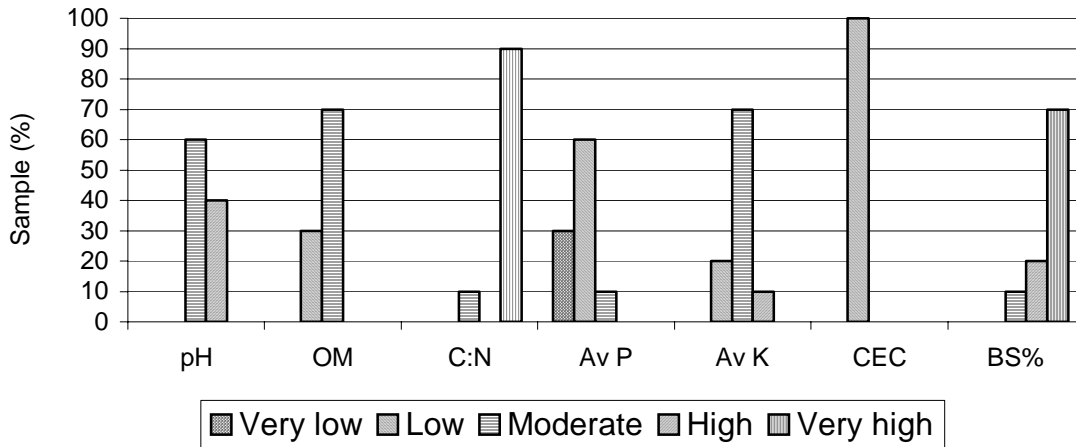


Figure 9 Soil parameters of potato fields in Changzee village.

iii. Soil result of Pangthang village (see figure 10)

The pH of the soils of this village is of medium range. The available K is distributed from low to high range with more than 50% in the low range while the available P is low for all the households. These low figures of P and K suggest the need to apply P and K containing fertilizers such as **SSP and MoP** respectively to improve the nutrient status of these soils. The organic matter content of these soils is of low to medium range with more than 75% in the low range while the C:N ratio is very high. The CEC of these soils is low with high BS%. Sandy clay loam is the major soil type of this village (figure 18). 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.

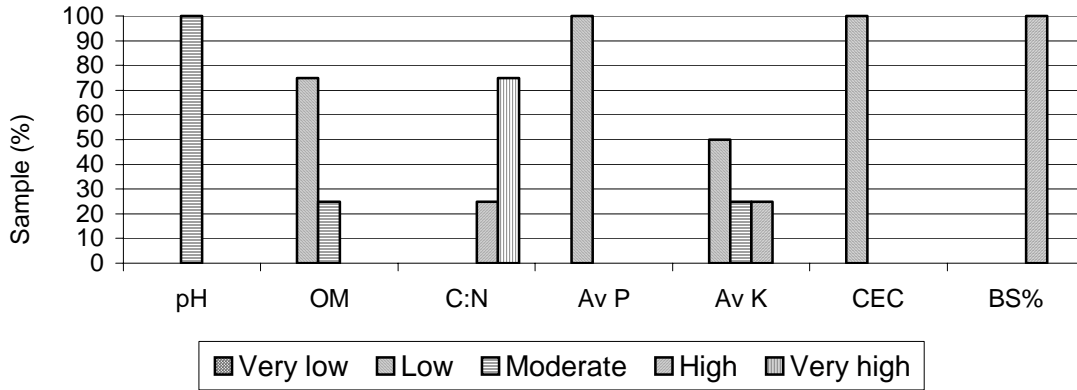


Figure 10 Soil parameters of potato fields in Pangthang village.

iv. Soil result of Minduling village (see figure 11).

The pH of the soils of this village is of medium to high range. The available K is within the medium to high range with almost 35% in the medium range. The available P of these soils is within the low to medium range with more than 65% in the low range. These figures suggest that there is the need to apply P and fertilizers such as SSP to improve the P status of these soils while the K values are fairly adequate. The organic matter content of these soils is of medium range with very high C:N ratio. More than 65% of these soils have low CEC values while the BS% of these soils is high. Three soil types are found in this village, viz. sandy clay loam, clay loam and loam (figure 18). These 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.

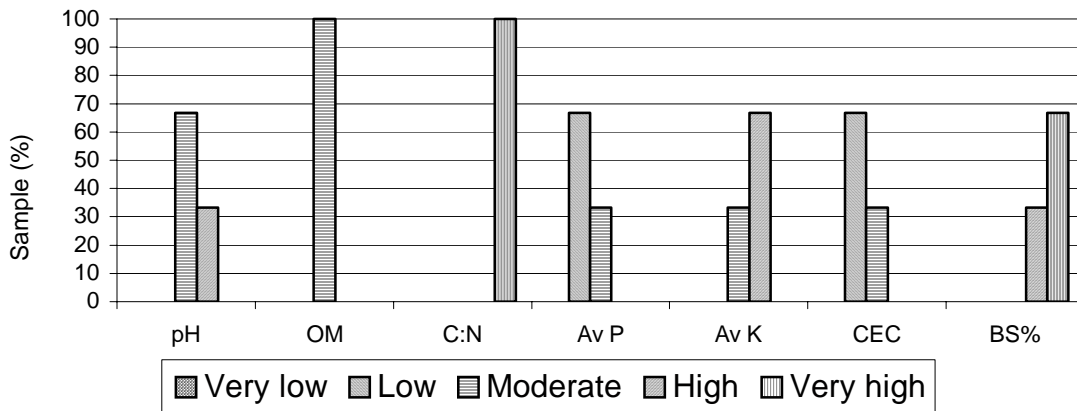


Figure 11 Soil parameters of potato fields in Minduling village.

v. Soil result of Tashiling village (see figure 12).

The pH of the soils of this village is mostly within the medium to high range. The available K is in the low to medium range with more than 35% in the low range while the available P is equally distributed between low, medium and high ranges (33% each). This figure suggests that there is a need to apply P and K

containing fertilizers such as SSP and MoP to improve these nutrients status of those soils having low P and K values. The organic matter content of these soils is of medium range and with very high C:N ratio. The CEC of these soils is of low to medium range with more than 65% in the low range. Incorporating more organic substances such as FYM can increase the CEC of these soils. The BS% range of these soils is very high. The major soil type is clay loam though loam is also found to a small extend (figure 18). Clay loam, a medium textured soil containing less than 40% clay content is the major soil type found in this village. For light textured soils, a split application of inorganic fertilizers especially urea (if applied) is advisable.

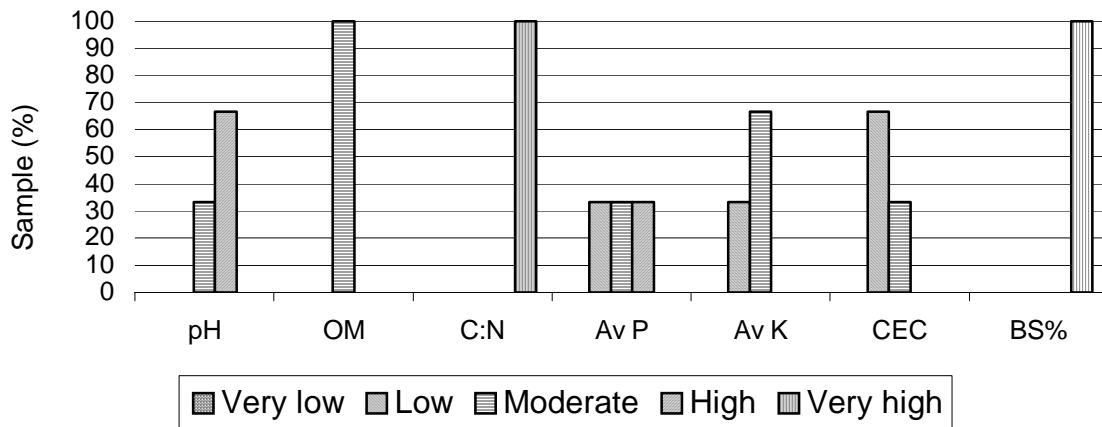


Figure 12 Soil parameters of potato fields in Tashiling village.

vi. Soil result of Baynang village (see figure 13).

The pH of the soils of this village is mostly within the medium to high range. The available K is in medium to high range with **40% in the medium range**. About **80% of these soils have low available P contents**. 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 of these soils is within the moderate to high range with 80% in the high range. The C:N ratio of these soils is high. The CEC values of these soils are mostly of medium range with very high BS%. The major soil type of Baynang is clay loam (figure 18). This soil type is of medium textured soils containing less than 40% clay content.

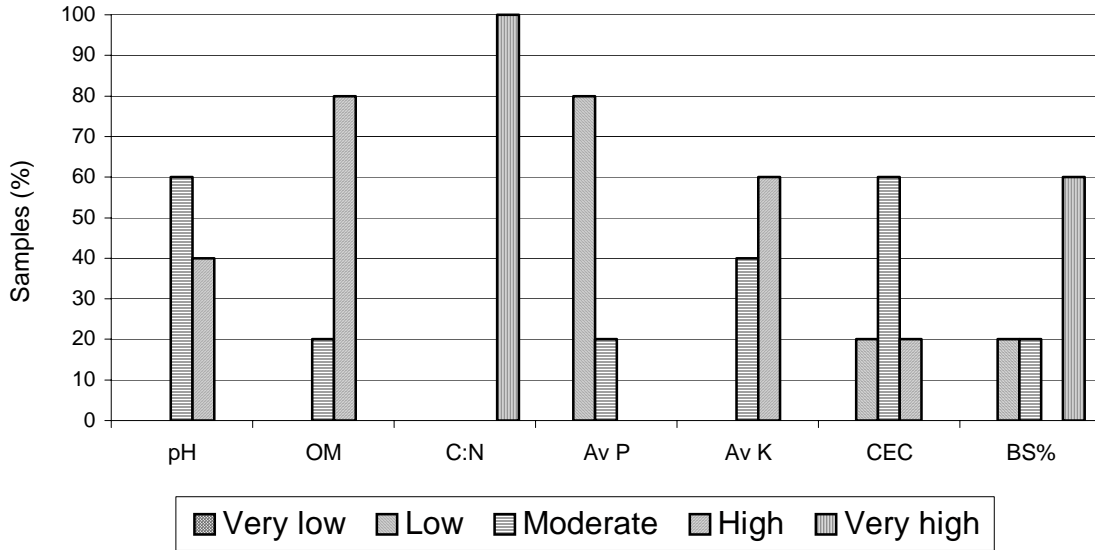


Figure 14 Soil parameters of potato fields in Baynang village.

viii. Soil result of Shingkhar village (see figure 15).

The pH of the soils of this village is of medium range. The available K is in the low to medium range with 50% in the low and another 50% in the medium range while all these soils have low available P. These low P and K figures suggest the need to apply P and K containing fertilizers such as SSP and MoP to improve the nutrient status of these soils. About 80% of these soils have high organic matter content with very high C:N ratio. The CEC of these soils is mostly within the low to medium range with low to very high BS% range. Clay loam, a medium-textured soils containing less than 40% clay content is the only soil type found in this village (figure18).

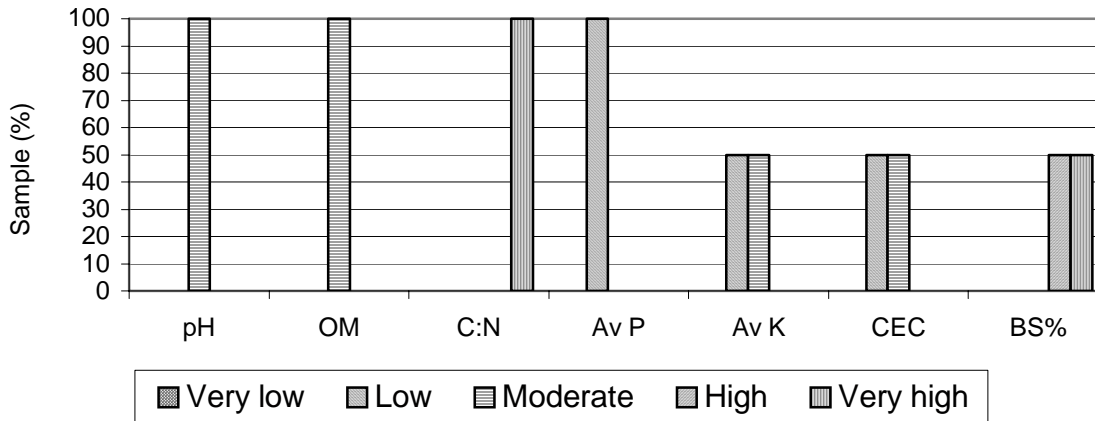


Figure 15 Soil parameters of potato fields in Shingkhar village.

ix. Soil result of Gongthung village (see figure 16).

The pH of the soils of this village is mostly of high range. This high pH could be due to added materials high in rich bases such as FYM (12t/acre of FYM applied) and ash from the burning of trash. The available K is within the low to medium to high range with more than 65% in the medium range. The available P of these soils is distributed from low to high range with almost 70% in the low range. These very low P and medium K 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 of these soils is of medium range with very high C:N ratio. The CEC of these soils is mostly within the low to medium range while that of he BS% is very high. Sandy clay loam is the most prominent soil type of this village (figure 18).

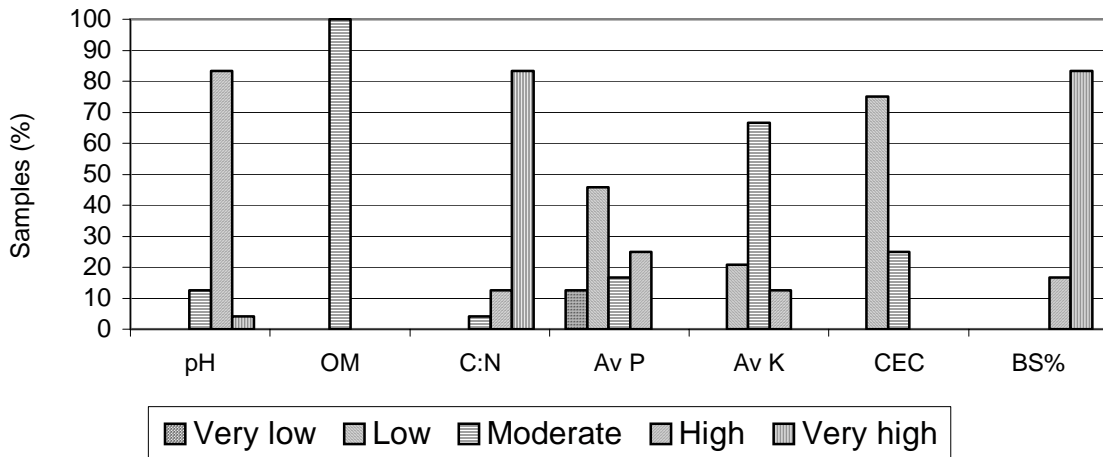


Figure 16 Soil parameters of potato fields in Gongthung village.

x. Soil result of Waiphung village (see figure 17).

The pH of the soils of this village is of high range. The available K is of **medium range**. **The available P content of these soils is low**. 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 of these soils is of medium range and these soils have very high C:N ratio. The CEC of these soils is low while the BS% range of these soils is very high. The major soil type is sandy loam, which is a light textured soil containing less than 20% clay content (figure 18).

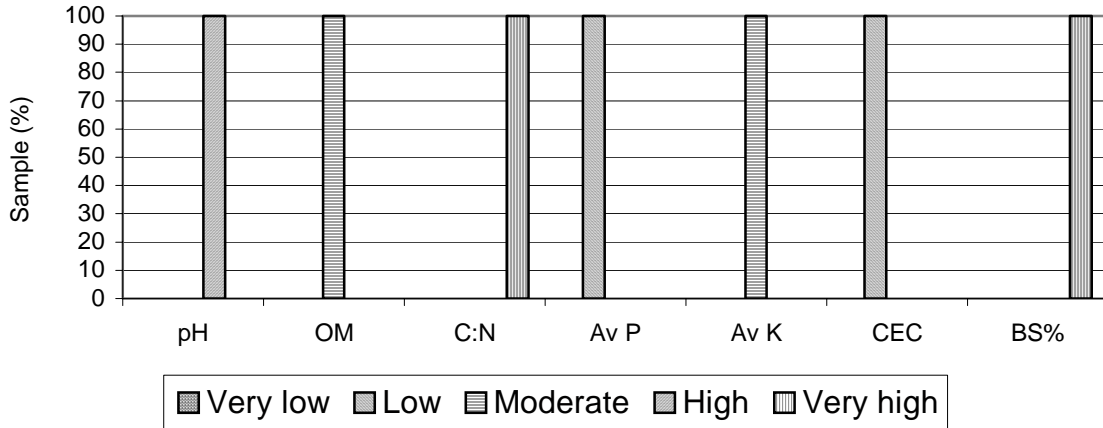


Figure 17 Soil parameters of potato fields in Waiphung village.

xi. Soil texture of different villages under Yangneer geog (see figure 18)

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

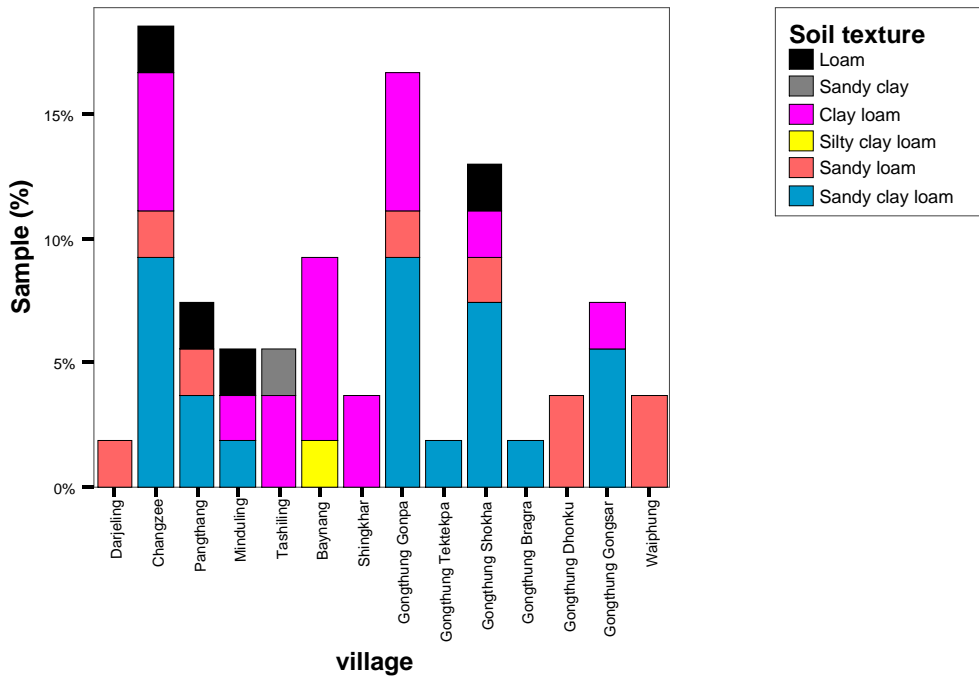


Figure 18 Soil textures of potato fields in different villages (Yangneer geog).

4. Conclusions

In Yangneer geog the potato fields are mostly located at the low altitude and medium range with the majority of the plots on the steep slopes and few plots and moderately sloping areas with east or north-easterly facing aspects with small land holdings. Desiree, a red variety is the most preferred potato variety of this geog as it fetches better price than the white variety. The potatoes are mostly planted in the month of February. Potato is intercropped with maize, which is sown within one to two months after planting potato. All the farmers of this geog apply Farm Yard Manure (FYM) to their fields with an average application of 12t/ac. FYM is usually broadcasted prior to ploughing. Other inorganic fertilizers like suphala and to a lesser extend SSP and urea is also applied to potato while urea is applied to maize as top dress. Almost all the farmers apply urea in a single dose either when the maize is of “knee high stage” of growth or at “pre-tasselling stage”. The average potato yield for Yangneer geog is 4.5t/ac while the average maize yield for this geog is 2.9t/ac. Tethering of cattle is not a common practice while all the farmers burn the crop residues prior to land preparation. The majority of the farmers of this geog do not practice tethering of cattle in the fields while all the farmers burn their trash after crop harvest prior to land preparation. The weeding frequency of the potato ranges from once to more than thrice while few farmers even weed more than three times.

In general, the soil pH is mostly within the moderate range while the available P and K content of these soils are mostly within the moderate range though few villages have low P and K contents. Therefore, the need to improve the soil nutrient status with regard to its P and K contents and hence the yield by applying P and K containing fertilizer such as SSP and MoP. The organic matter content is within the moderate range. Most of the soils have high BS% while the CEC content is low and incorporating more FYM could increase the CEC values. Sandy clay loam and clay loam are the dominant soil types of this geog.

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 the soils in most of the villages is mostly within the low to medium range though on an average it is of medium range while few villages have low values and for these low values, applying P containing fertilizer such as SSP together with urea as a basal dose could improve the P content in these soils.
- ☞ The available K content of these soils is mostly of medium range. Though K might be adequate for those villages with moderate values, it might not be sufficient for those with low K values and hence the need to apply K

containing fertilizer such as MoP to replenish the K content. In addition, potatoes are efficient removers of K. and therefore the need to apply it into the soil.

- ☞ The CEC of most of these soils is within the low to medium range and this low value indicates that almost all the major macronutrients are required to obtain adequate yield.
- ☞ An application of balanced nutrients with proper recommended rate needs to be encouraged. For this geog, more than one set of recommendation needs to be encouraged, viz. for those villages with low values for both P and K and the other set for those with only one nutrient in the lower range (for the village grouping refer the following table 1). 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.

A. Thus the recommended rate of 100:100:100 kg/ha of N,P,K (i.e. for those villages with low values of both P and K) :

1. Using Suphala is as follows:

- Apply about 270 kg/acre of Suphala as basal dose during land preparation (i.e. about 5¹/₂ bags of Suphala @50 kg per bag per acre) as one straight dose or
- Apply about 216kg/acre of suphala as basal dose during land preparation (i.e. about 4¹/₃ bags of suphala @50kg per bag per acre) together with 50kg of SSP (i.e. 1 bag of SSP @50kg per bag per acre) and about 14 kg of MoP as basal dose; followed by about 17 kg of urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (i.e. when the maize plants are of “knee high” stage).

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

- Apply 69kg/acre of Urea as basal dose during land preparation (i.e. about 1 bags of Urea @50 kg per bag per acre).
- Apply about 253kg/acre of SSP as basal dose during land preparation (i.e. 5 bags of SSP @ 50 kg per bag per acre).
- Apply about 67kg/acre of MoP as basal dose during land preparation (i.e. about 1 bag of MoP @ 50 kg per bag per acre).
- Followed by 17 kg urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (i.e. when the maize plants are of “knee high” stage).

B. Thus the recommended rate of 100:100:80 kg/ha of N,P,K (i.e. for those villages with low P values):

1. Using Suphala is as follows:

- Apply about 216 kg/acre of Suphala as basal dose during land preparation (i.e. about 5¹/₃ bags of Suphala @50 kg per bag per acre)
- together with 51kg/acre of SSP as basal dose during land preparation (i.e. about 1 bag of SSP @50kg per bag per acre)
- Followed by about 17 kg/acre of urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (i.e. when the maize plants are of “knee high” stage)

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

- Apply 69kg/acre of Urea as basal dose during land preparation (i.e. about 1 bags of Urea @50 kg per bag per acre).
- Apply about 253kg/acre of SSP as basal dose during land preparation (i.e. 5 bags of SSP @ 50 kg per bag per acre).
- Apply about 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 17 kg urea as top dress either when the plants are of 15-20 cm high (after 30-45 days of planting) or at the time of potato flowering (i.e. when the 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.

☞ 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.

☞ Urea topdress of incorporating it into the soil needs to be encouraged as all the farmers reported of broadcasting it without incorporating it into the soil.

Table 1. Village categorization for fertilizer recommendations.

Villages	
Low P & K values²	Low P with medium K values³
Pangthang	Darjeling
Tashiling	Minduling
Shingkhar	Baynang
Changzee	Gongthung
Gongthung	Waiphug

² Fertilizer recommendation of N:P:K of 100:100:100 kg/ha

³ Fertilizer recommendation of N:P:K of 100:100:80 kg/ha