REPORT 8

Strategies for improved fodder production in the dry season in the mid-hills of Nepal, using participatory research techniques.
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Characterisation of the soil fertility to identify its implication for the fodder production in the research sites.

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LIST OF ABBREVIATIONS

C	Carbon
DFID	Department for International Development
DFRS	Department of Forest Research and Survey
K	Potassium
NAF	Nepal Agroforestry Foundation
NGO	Non Governmental Organisation
NRI	Natural Resources Institute
N	Nitrogen
P	Phosphorus
RNRKS	Renewable Natural Resources Research Strategies
VDC	Village Development Committee

GLOSSARY OF NEPALI TERMS

Badahar	*Artocarpus lakoocha*
Bari	Rainfed land that receive no additional water
Bhatmase	*Flemingia congesta*
Dinanath	*Pennisetum pedicillatum*
Guazuma	*Guazuma ulmifolia*
Ipil	*Leucaena diversifolia*
Kimbu	*Morus alba*
K-156 G. NB-21	*P.purpureum x P.americanum.*
Molasses	*Melinis minutiflora*
Stylo	*Stylosanthes guianensis*
Tanki	*Bauhinia purpurea*
Velvet bean	*Mucuna pruriens*

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Summery

Soil survey was carried out in the research sites at Gajurichhap and Gauthale of Dhanding, Tawari and Chankhubensi of Kavrepalanchok and Ange of Sindhupalchok Districts of Nepal from 18 November to 9 December 1999. The main objective of the study was to assess the fertility status and to find out it's implication for improved fodder production. Site selection and plantation works were carried out using participatory techniques.

Site characteristics were recorded and soil samples were collected from four depths each at 0-20 cm, 20-40 cm, 40-100 cm and 100-200 cm respectively of each terrace riser. Soil tests were carried out for pH, texture, exchangeable potassium, total nitrogen, organic carbon, and available phosphorus in all the samples

The soils in the majority of the sites were well developed with two to three distinct horizons. There were some variations in physical characteristics such as colour, stone content and texture of the soils in the study plots. There were marked differences in all the chemical properties of soil across the five villages. The variation in the content of nutrients, except nitrogen and organic carbon, within the village were insignificant. The soils in general ranged from poor to medium and were acidic in nature with pH ranging from 4.65 at Chankhubensi to 6.11 at Gajurichhap. The nutrient contents in 0-20 cm, 20-40 cm, 40-100 cm and 100-200 cm depths were found to be highest in the soils at Tawari, Chankhubensi, and Gauthale respectively.

The farmers were commonly found to apply urea and compost to sustain the fertility of their bari land. There were marked differences in the amounts of urea and compost applied by the farmers across the village, however, they were not significantly correlated with organic carbon and nitrogen content of soil.

The survival and growth of Ipil differed significantly across the villages. While these differences in the other two species remained insignificant. The survival of Ipil ranged from 45.1% at Chankhubensi to 84.8 at Gajurichhap. The growth of Ipil was highest at Gajurichhap and lowest at Ange. The pH of the soils correlated markedly with survival and growth of Ipil. The correlation of survival and growth with other nutrients of soils and application of urea and compost were poor.

The physical conditions such as soil depth, drainage, texture and structure in most of the sites were favourable for survival and growth of Badahar, Kimbu and Ipil. Nonetheless, low pH and insufficient available essential nutrients in the soil seems to be partly responsible for the poor growth and survival of the seedlings. Besides these, lack of proper care, limited available moisture, high stone content and unfavourable microclimatic conditions may also have hindered the growth of the seedlings to some extent. The growth and survival, however, can be partly improved through application of the recommended doses of lime, fertilizer, and compost with proper moisture conservation measures. There is a great potential for fodder production in these sites.

1. Background

Tree fodder and green grasses are important sources of animal feed in the hill of Nepal. About 42 per cent of the total nutrient demand of ruminants are fulfilled from these sources (Pandey, 1990). The demand for foliage biomass from the farm trees has been increasing due to decline in forest resources (DFRS/FRISP, 1999) and high growth in livestock population (CBS, 2000). As a result more and more trees are being planted on the farmland (Gilmour, 1988). But many planted trees die simply due to wrong choice of the species for particular site (Ghimire and Neilsen, 1985; Demanski and Bashyal, 1990).

In order to assess suitability of sites for different fodder species such as: *Artocarpus lakoocha, Morus alba, Leucaena diversifolia and* few other species fifty experimental plots were established in five villages in three hill districts of Nepal. The study was started in 1997 as a collaborative research project and remained for three years. The project was funded by the Department of International Development (DIFD) and was implemented by DFRS in collaboration with NAF.

In the first year of the project, research sites were selected and plantation works were carried out. Latter in the second year, the staff of Soil Section of DFRS visited all the research sites and carried out soil survey in all the experimental plots from 18 November to 9 December 1999. The main objective of the visit was to examine the effect of inter-site variation in soil properties on the survival of fodder species and to assess their potentiality for fodder tree plantation

2. Objectives

The purpose of this study is to examine the site and soil characteristics of the experimental plots, to assess their potentiality for fodder tree plantation. The other objective is to study the indigenous fertilizer management practice and to find out its implication in fertility improvement.

3. Methodology

3.1. Site selection and plantation

A participatory method was used for the selection of the all the research sites (Hada et al., 1997). The method consisted of two surveys, conducted by the staff of the NRI and NAF with the various communities in Dhading, Kavre and Sindhupalchok Districts. On the basis of information obtained from first survey, partner NGOs suggested potential research sites which was latter confirmed by second survey (Kiff et al., 1998). Finally, five sites viz. Gajurchhap, Gauthale, from Dhading District, Tawari, and Chankhubensi from Kavrepalanchock District and Ange from Sindhupalchok were selected for the study. Gajurichhap and Gauthale are located north of Kathmandu to Mugling highway. Tawari is situated near Khopasi the nearest town on the Dhulikhel road. Likewise Ange is located near Tipeni which has access to Kathmandu. Chankhubensi is situated 30 minutes walk from Arniko highway

In each village ten experimental plots were laid out (Kiff et al., 1999). Each plot had 20-meter long terrace with the riser of about 2-meter deep. Different trees and grasses were plated on the risers. The combinations of the tree and grass seedlings were different in each of the five villages, however, it was the same within any one village. The species like Badahar, Ipil and Kimbu were common to all villages. Diagram below shows the lay out of the experiment over 10 meter, which is half the actual field size, for all five villages.

The plantation work was carried out during the monsoon 1998 with the participation of the farmers and the staff of Department of Forest Research and Survey (DFRS) and Nepal Agroforestry Foundation (NAF). The spacing between all seedlings was approximately 50 cm. In the middle the grasses were planted 25 cm apart. Measurements on the survival percentage were made every two months after plantation. The data presented in this paper is six months after transplanting.

Figure: Diagrams of planting pattern

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               A  F  E   F  A  F  E   F  A  F  E   F  A  F  E   F  A  F  E  F  A        (Top)
              -X--x--X--x--X--x--X--x--X--x--X--x--X--x--X--x--X--x--X--x--X--
Stylo         xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Molasses      xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
               X-----X------X------X-----X-----X-----X-----X-----X-----X-----X--      (Base)
               B     B      D      B     B     D     B     B     D     B     B
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A. Ipil (*Leucaena diversifolia* K-156)
B. Kimbu (*Morus alba*)
C. Tanki (*Bauhinia purpurea*)
D. Badahar (*Artocarpus lakoocha*)
E. Bhatmase (*Flemingia congesta*)
F. Guazuma (*Guazuma ulmifolia*)
G. NB-21 (*P.purpureum x P.americanum*)
H. Molasses (*Melinis minutiflora*)
I. Dinanath (*Pennisetum pedicillatum*)
J. Stylo (*Stylosanthes guianensis*)
K. Velvet *bean (Mucuna pruriens*)

3.2. Soil survey

In each research plot, at first the site characters like aspect, slope, altitude and vegetation were recorded and were followed by a soil profile study. The DFRS' record sheet lists all the important information that needs to be collected to describe the location of the soil pit and the site condition. In this study, instead of digging a pit, the exposed part of the terrace riser was used for soil profile examination. The vegetation and thin top soil of about 30 cm wide from top to bottom from the surface of the terrace riser was removed using a spade so that various horizons were exposed and clearly seen. This operation was done at three points across the terrace riser: one at the middle and the other two at two extreme ends. The profile was examined for horizon, colour, mottling, texture, structure, consistency, stone content, horizon boundary, pH and other special features.

3.3. Soil sampling

A composite soil sample was taken each from 0-20 cm, 20-40 cm, 40-100 cm and 100-200 cm depth from each profile and was collected separately in four different plastic buckets numbered separately. The samples thus collected in each bucket were thoroughly mixed. About 500 g of thoroughly mixed composite sample from each bucket was placed in a plastic bag and was sealed with rubber band. Each sample bag was properly labeled and was taken to the laboratory for the analysis.

The soil samples collected from the field were placed separately in shallow plastic trays and were allowed to dry in the air in shade. After a week the dried samples were crushed gently with mortar and were passed through 2-mm sieve. About 250 g of each sieved sample was poured into a clean and properly labeled plastic bottle and was covered with screw cap and stored for the analysis.

3.4. Soil analysis

The air-dried soil samples were analysed for pH, texture class, total organic carbon, total nitrogen, available phosphorus and exchangeable potassium. The tests were carried out following the methods by Anderson and Ingram (1993).

3.5. Indigenous soil fertility management survey

A checklist of required information was prepared before carrying out the survey. In the field each farmer involved in the management of the experimental plots was asked to explain about the major agricultural activities linked with fertility management. One or two questions were also asked to lead the farmers to the point which farmers missed during conversation. The necessary information was recorded during the talk and was arranged later in the order of the checklist. The information collected mainly pertained to organic compost and chemical fertilizer application.

4. Results

Results compared within village

4.1. Gajurichhap

Gajurichhap village is situated in Kumpur VDC, Ward no. 3 of Dhading District. The village is located half an hour's walk, north of Gajuri village which is on the main Kathmandu to Mugling highway. The climate is subtropical.

4.1.1 Site and profile description

The results of site survey and profile descriptions are given in Appendix 1. The study sites were located at different altitudes. The highest, Tawari is at 1750 masl, the two mid-altitude sites of Ange and Chunkhubesi between 1000-1200 masl and two low-altitude sites of Gauthale and Gajurichhap at 650m and 790 m. The majority of the sites have an easterly aspect, however, some sites have north to north-easterly aspect. The slope gradient ranges from 21^o to 40^o.

All the study plots have deep and well-drained soil with no evidence of any mottling. The depth of soil ranges from 1 m to 2 m. There are three horizons (A2, B2 and B3) in all most all the plots, except in one which has A1 and A2 horizons only. The occurrence of A1 and A2 horizons may be due to the excessive accumulation of organic matter when it was still a forest. This plot has only recently been put into cultivation. Soils in all the sites have invariably sub-angular blocky structure and are friable. There is presence of stone in every site and the size varies from small to large. The frequency of occurrence of stone also differs from site to site. Besides two plots (Top Bahadur and Dhana Bahadur) which have medium sized stones, all the others have the small sized stones.

4.1.2. Soil Properties

Of the ten study plots, nine plots have loamy texture at all depths (Appendix 2) and one plot has clay loam texture. The higher level of clay in one plot is probably due to the inherent quality of the parent material.

Appendix 2 shows that the soil reaction in all the ten plots vary from 5.71 to 6.48. The difference in pH across the sites is wider than within the site. The pH of the site 1 is the lowest (pH 5.71 -5.83) while the site 7 has the highest pH (6.42-6.48) at all depths. The pH of the top layer is generally higher than the other layers this may be attributed to the presence of higher organic matter on the surface layer. In all sites the pH of the top layer is lower that the other layers this seems to be due to the leaching of the organic matter and basic cations present in the soil in the lower layers.

The study plots differ greatly in total organic carbon, total nitrogen, available phosphorus and exchangeable potassium contents. The difference contents of these elements are more pronounce across the plots than within. Exchangeable potassium present in soil ranges from 0.04 to 0.54 me (Appendix 2). Except three plots, others have highest exchangeable K in the top layer and this gradually decreases down the layer. The lower level of Kin the top layer in three sites may be attributed to the excessive leaching. The site 6 has the highest level of K (5.4 me) while the site 1 has the lowest K (0.04 me).

The per cent of total nitrogen in the soils range from 0.03 to 0.18. The highest level of nitrogen is found in the site 8 while the lowest was in site 4 and 5. The upper layers in most of the sites have higher level of total nitrogen, which is obviously due to high level of organic carbon and this successively decreases in the lower layers. Unlike other sites site 2 and 5 have the top layer with low level of total nitrogen and this can be attributed to the leaching of the soluble nitrogen compounds in the lower layers.

The contents of total organic carbon vary from 0.30 - 1.51%. The plots 2, 6 and 9 have the highest level of organic carbon while plot 7 has the lowest. The concentration of the element is generally high in 0-20 cm and this gradually falls in 20-40, 40-100 and 100-200 cm depths. In case of plot 2 the amount of organic carbon in the topsoil is the lowest and this successively increases as it goes down the profile. The high value of the element at 100-200 cm is presumably due to the presence of a buried horizon. The higher values of organic carbon in the second and third layer compare to the top layer appear to be due to leaching.

The available phosphorus is generally low in most of the study plots. It varies from 0.12 to 15.23 ppm. The highest level of phosphorus is present in the plot 6. In contrast the plot 7 has the lowest concentration. Like other elements the concentration of phosphorus also decreases with the increase in depth of the profile. In plot 1, unlike others, the level of phosphorus in the 20-40 cm is extremely high. This can be attributed to the excessive leaching of the element. In plot 8 also the available phosphorus in the 40-100 and 100-200 cm depth is slightly higher than the top layer. This is probably due to the leaching of soluble phosphate from the top and second layer to the third and fourth layers.

4.2. Gauthale

Gauthale village lies in the Salang VDC ward no 9 of Dhading District. It is located 45 minute's walk, by local calculation, north from the main Kathmandu to Mugling highway, and 30 minute walk from Parewa Tar on the Dhading road. The climate is sub-tropical, but extremes of hot and cold are experienced in summer and winter.

4.2.1. Site and profile description

Appendix 1 gives the site and profile characteristic of all the study plots at Gauthale village. The ten sites selected for the study were all bari land. The altitude of the site range from 520 m to 800 m. Plot 11 is situated at lowest altitude while the plot 14 occupies highest altitude. The slope gradient varies from 21 to 40. Of the ten plots five plots have south aspect; two plots have easterly; another two plots have northwest; and one plot has northern aspect.

The soil in each site is deep with the average depth of 2 m. Each plot consists of three horizons namely A2, B2 and B3. All the plots have fairly good drainage, which is also evident from the lack of mottles in the site. The majority of soils are friable with subangular blocky structure, however, the plot 14 has round and crumb structure with loose and powdery consistence. The stones are present in all the sites and their size range from small to large and their frequency range from few to common.

4.2.2. Soil properties

Table lists the properties of the soils present in ten sites at Gauthale. The textures of the soil vary greatly among the sites. The textural difference within the site is minimal. Majority of the sites have Clay Loam texture, although some other textural groups such as silt loam, silt clay loam, loam are also present within the site. The plots 14 and 19 have purely loam texture. Similarly, the plot 17 has entirely silt clay loam texture. Two plots (18, 20) have four different textures namely: silt loam, loam, silt loam, and clay loam at 0-20, 20-40, 40-100 and 100-200 cm respectively.

The pH of soil differ from plot to plot and within the plot also. It ranges from 5.20 to 6.49 across the plot. In half of the plots, pH decrease gradually from top to bottom, which may be due to higher percent of organic carbon and clay content that binds and prevents the basic cations from leaching downwards. In contrast in the remaining plots opposite is the trend, which can be attributed to the leaching of the basic cations down the profiles.

Exchangeable potassium contents in various plots range from 0.08 me to 1.03 me (Appendix 2). The plot 13 has the highest level of K (1.03 me) while the plot 14 has the lowest K (0.08 me). Of the ten plots, 8 plots have higher exchangeable K in the top layer and this gradually decreases down two layers below and again it goes up. The higher amount of potassium in the 0-20 cm depth is probably due to the higher amount of the organic carbon, which is a good source of exchangeable cations. The sudden rise in the exchangeable K in the 100-200 cm depth might be due to the presence of potassium rich parent material in the soil. The plot 18 shows reverse trend with the concentration of the element increasing downward while the plot 17 shows no trend at all. The lower level of potassium in the top layer in one site may be attributed to the excessive leaching.

The research plots vary in the total nitrogen content. The element present in the soils of the various plots range from 0.05% to 0.15%. The plot 11 has the highest level of nitrogen while the plot 14 has the lowest. The upper layers in most of the sites have higher level of total nitrogen and this successively decreases in the lower layers. The plots 17 and 18 have quite homogeneous distribution of nitrogen down the profile. The higher value of nitrogen in 0-20 cm can be attributed to high level of organic carbon in this layer.

There is a considerable difference in total organic carbon present in the various plots. The difference also exists between the depths of the same plot. The per cent of total carbon existing in the soil vary from 0.34 to 1.68. The plot 13 has the highest level of organic carbon while plot 20 has the lowest. The level of organic carbon is generally high in surface layer and the concentration gradually falls in the lower layers. Unlike other plots, carbon concentration in the plot 16 gradually increases down the profile. This appears to be due to leaching of the organic carbon from the upper layer.

The available phosphorus is relatively higher in this village than Gaujurichhap. The phosphorus content in the soil ranges from 0.82 to 71.92 ppm. The highest level of phosphorus is present in the plot 18. In contrast the plot 7 has the lowest concentration. The amount of available phosphorus in soil varies with the depth. The concentration of the element is higher in the upper layers and decreases in the subsequent layers of the profile. In plot 11, unlike others, the level of phosphorus in the 20-40 cm is extremely high. In the plots 18 and 19 the level of phosphorus gradually decreases up to 100 cm and it again increases below it. This can be attributed to the excessive leaching of the element. In plot 18 also the available phosphorus in the 40-100 and 100-200 cm depth is slightly higher than the top layer. This is probably due to the leaching of soluble phosphate from the top and second layer to the third and fourth layers.

4.3. Tawari

Tawari village falls in ward no 5 of Mahankalchour VDC in Kavrepalanchok District. The village is situated three and a half hour's walk from Khopasi, the nearest town on the Dhulikhel road at an altitude of 1,750 m. Most of the housed are located on the north-west facing slope. It has cool temperate climate.

4.3.1. Site and profile description

All the sites are high bari land and are situated on the easterly and north easterly aspect (Appendix 1). The altitudes of the sites vary from 1600 m to 1840 m and their slope range from 22 ^{o} to 42 ^{o}.
All most all the sites have deep and well-drained soil. The parent rocks in the majority of the sites were not observed up to 2 m depth. In contrast the plots 22 and 27, the parent material was found within 1m. The profile studies of the various plots show that there is common occurrence of two horizons viz. A2 and B2. Nevertheless some plots (plots 24,28 and 29) also have three horizons (A2, B2 and B3). Interestingly, the plot 25, in particular has only one A1 horizon extending up to 2 m. This may be due to heavy accumulation before it was converted to agricultural land and application of organic matter during cultivation. The soils in the various horizons have sub-angular blocky structure and have friable and sticky consistence. The occurrence of stone is common in all soils except plot 25, which is absolutely free of it. There is a great variation in the size and frequency of the stone. The size range from large to small and frequency vary from few to many. Besides the plot 29 and 26 which have large and medium sized stones, all other have small and few stones. Abundant root hairs were found in all sites at all depths.

4.3.2. Soil Properties

The results of laboratory analysis show that there is a great resemblance in the texture of all soils at Tawari. All the plots, except five, have silt loam texture (Appendix 2). Of the five plots having different texture from the former, two plots (22 and 24) have loamy texture at 20-40 cm and 100-200 cm depth. The remaining three plots (plot 25 at 40-100 cm; plot 26 at 100-200 cm and plot 28 at 80-100 cm depths) have silt clay loam texture.

The soil at Tawari is overall acidic. There is very little variation in the pH of the soil within and across the various plots. It ranges from 5.30 to 5.81. The plot 23 has the lowest pH while plot 26 has the highest pH. The profiles in half of the plots show a decrease in pH as it goes downwards while other half plots show a reverse pH trend.

The research plots differ widely in their exchangeable potassium content. The minimum and the maximum level of potassium falls between 0.07-0.59 me. The highest level of potassium is present in the plot 24 and the lowest is found in the plot 29. In all the plots the concentration of the potassium decreases downwards which can be attributed to the gradual change in the organic carbon content along the profile.

The levels of total nitrogen present in the Tawari research plots are generally medium to low level. The per cent of nitrogen vary greatly among the plots. The contents of the element also differ within a plot at different depths. The concentration of the nitrogen range from 0.01 to 0.18 per cent. The lowest per cent (0.01%) of nitrogen found to occur in the plot 24 at 100 to 200 cm depths while the highest per cent (0.18 %) of the element present in the plot 25 at 40-100 cm depth. The upper layer has higher per cent of nitrogen and the lower depth has the lowest in all most all the sites.

The per cent of total carbon present in the research plots vary substantially across and within the plots. The concentration of nitrogen ranges from very negligible amount present in the plot 24 to highest 2.31 per cent in the plot 29. The amount total carbon in the various plots falls between very low to high level from the fertility point of view. The variation is primarily due to the difference of organic carbon input source. Like total nitrogen the concentration of total carbon also show a gradual decline with increase in the depth within a profile.

The amounts of phosphorus available in the soil of the majority of the plots are low. Nonetheless, in some plots the concentration of the element is found to medium and high as well. There is a great difference in the content of available phosphorus across the plot and it ranges from 0.35 ppm to 21.63 ppm. The highest value of element (21.63 ppm) is present in the plot 30 at 0-20 cm depth while the lowest value is found to be in the plots 26 and 28. The variation in the content of available phosphorus also exists at different depths within the plots. The general trend is the gradual decrease in the concentration of the phosphorus from top layer to bottom layer. In plots 21 and 22 the distribution of element is other way around.

4.4. Ange

Ange lies in the Langarche VDC ward No. 9 of Sindhupalchok District. It is situated 45 minutes walk from Tipeni where there is road access to Kathmandu. The village is facing towards southwest and is located at an altitude of 1500 m asl.

4.4.1. Site and Profile characteristics

Majority of the sites, except one high bari land, are medium bari land with soils having wide range of colour. Majority of the soils has dark yellowish brown or brown/dark brown colour. The details about site and profile are given in the Appendix 1. The sites are located at various altitude and aspects ranging from west, southwest to northern. The altitude range from 1100 m to 1770 m asl. The plot 32 is located at highest altitude while the plot 31, 39 and 40 are at the lowest.

4.4.2. Soil properties

Each plot has deep soil with depth extending up to maximum 2 meters. Most of the profiles in the plots have three horizons viz. A2, B2 and B3 and each horizon has sub-angular blocky and friable soils with sticky consistence. Unlike others, soil in the plot 37 has round structureless, powdery soils with loose consistence. The stones were completely lacking in most of the soils, except in case of plot 35 and 40 which has few small stones. The drainage of all the plots appear to be rapid with no indication of any mottling.

Appendix 2 shows that there is very little variation in the soil texture. Most of the plots have of sandy loam texture while the plot 40 at 100-200 cm depth has sandy clay loam texture. The textures of some of the plots fall on the borderline of sandy loam and loamy sand. Likewise, the plot 32 and 40 lie on the borderline of Sandy clay loam and loam and sandy loam and sandy clay loam respectively.

The soil reaction of all the plots belongs to the very acidic group and differ quite significantly across the plots. The pH range from 4.87-5.80. The plot 33 has the highest pH while the plot 40 has the lowest pH. In all most all the plots the pH of the upper layer is the lowest and it gradually increases in the successive layers. The gradual increase in the pH with increasing depth can be attributed to the leaching of the basic catinons from the top layer.

The content of exchangeable potassium, total nitrogen, organic carbon and available phosphorus in the soils vary significantly within and across the plots. The concentrations of these elements are generally high in the top layer. In the successive layers the amount of these elements gradually decrease. This is probably due to the higher input of organic matter and fertilizer on the upper layer and this is redistributed in the other layer through leaching. Exchangeable potassium present in the soil ranges from 0.07 to 1.18 me. The highest amount of this element is present in the plot 33 while the lowest concentration is found in the plot 38. Similarly, the concentration of total nitrogen range from 0.01 % to 0.13 %. The per cent of organic carbon in the soils vary from 0.13 to 1.48. The highest percentages of organic carbon and nitrogen were present in the plot 33 while the lowest values of those elements were found in plot 38. The available phosphorus occurring in the soil varies from 1.29 ppm to 186 ppm. Unlike in the other plots, the available phosphorus in the plot 39 and 40 at the lower depths show gradual increase in the concentration. This appears to be due to the higher per cent of clay fraction, which adsorb the phosphate leaching from upper layers.

4.5. Chankhubensi, Nayabasti and Nayagaon

Chankhubensi, Nayabasti and Nayagaon are situated in ward No. 6 of Dhulikhel Municipality in Kavre District. These villages are located 30-45 minute's walk from the main Arniko highway. These villages are facing north through to east and are situated at altitude of 1,200 m asl.

4.5.1. Site and profile description

Most of the sites are low bari land situated at an altitude ranging from 600 m to 1350 m. The plot 41 is situated at the highest altitude while the plot 42 is at the lowest. The sites are facing north through to east.

All the plots have deep and well-drained soils. The depth of soil in each plot, other than plot 43, extend up to about 2 m. The plot 43 has about 1 m depth. The results of the profile study show that out of ten plots 4 plot have three distinct horizons. The horizons are A2, B2 and B3. The other six plots have only two horizons namely, A2 and B2. The soil with friable consistence and sub-angular blocky structure is common in all the plots. Each plot has few medium sized stones in the soil.

4.5.2. Soil properties

About 90 per cent of the soil in the experimental plots have loamy texture. Of the remaining 10 per cent, 9 % (plot 44) have coarse soils with sandy loam texture and 1% (plot 43) has fine soil with silt clay loam texture.

The pH of the study plots falls in the very acidic range with the value lying between 4.60 to 5.76. The plot 49 has the highest pH whereas the plot 41 has the lowest. The difference in pH within the plot is insignificant, however, the variation across the plots is quite significant. The pH shows a gradual increase down the profile in half of the plots while in other half it shows opposite pattern.

The amount of exchangeable potassium, total nitrogen, organic carbon, available phosphorus present in the soil vary greatly within the plot and across the plots. The concentrations of these elements are commonly higher in the upper layer and decrease successively in the lower layers. In case of exchangeable potassium, in the plot 49 have the higher concentration at 100-200 cm depths, this may be due to the presence of potassium rich parent material near to this layer. The concentrations of exchangeable potassium range from 0.05 to 1.35. The highest amount of potassium is present in the plot 49 while the lowest is found in plot 50. Likewise the per cent of nitrogen and organic carbon vary from 0.02 to 0.13 and 0.48 to 1.60 respectively. The highest per cent of total nitrogen and total organic carbon occur in the plot 43 whereas the lowest percent of these elements present in the plots 50 and 48 respectively. The concentration of available phosphorus range from 1.37 ppm to 276 ppm. The plot 49 consists of highest available phosphorus while the plot 50 has the lowest. The higher concentration of these elements in the topsoils appears to be due to the application of the compost and chemical fertilizer. These added compounds are leached to the lower layer in little amounts only.

4.6 Results compared across the village

4.6.1. Site and profile description

All the study plots in the five villages, irrespective of their differences in the altitude and aspect are invariably a bari land. The effect of irrigation in this study has been eliminated, however, the amount of precipitation will still have some role in the growth of fodder trees. There is a substantial difference in the altitude of the sites in the five villages. Tawari occupies the highest place with the altitude range of 1600 to 1840 m. It is followed by Chankhubensi (1190m-1360m), and Ange (1100m-1790m). Although Ange's one plot has higher altitude than Chankhubensi, its all other plots have values below than the latter. Gajurichhap (650m-790m) and Gauthle(520m-790) have more or less similar elevation range.

There is a difference in the aspect of the various sites established for the study. The sites at Gajurichhap, Tawari and Chankhubensi have quite similar aspect. Majority of them is facing towards either northern or eastern or northeast. There are only one or two site facing towards southern. The sites at Gauthale village have either southern or northern or northwest aspect, except two having eastern aspect. In case of Ange half of the sites are facing southwest and other half towards west.

The soils in all the villages are generally very deep with distinct horizons. There is presence 2 to 3 horizons in all the plots. In most of the cases the horizons are A2 and B2 or A2, B2 and B3. However, in the plot 9 at Gajurichhap and plot 25 at Tawari have A1 and A2 horizons only. There is a great resemblance in the structure, consistency of the soil across the villages. Although drainage is not a problem in any of plots, it may differ across the village depending on the texture of the soil. The occurrence of stone in the soil is common in all the plots. Nevertheless, Ange has relatively fewer stones than other four villages. Interestingly, the plot 9 at Gajurichhap and plot 25 at Tawari too have no stones.

4.6.2. Soil properties

The five research sites vary greatly in their soil texture ranging from coarse to fine soil . Ange has in average coarse to very coarse soil with sandy loam to loamy sand texture while Gajurichhap and Chankhubensi have generally medium soil with loamy texture. The soils at Tawari have quite fine soil having silt loam texture. In contrast, Gauthale has relatively fine soil with the texture either clay loam or silt clay loam.

Table 1 gives the average values of chemical properties of all the villages. The five villages differ significantly at all depths in their soil reactions. However, the variation within various soil depths of one village is insignificant (Table 2). The soil pH in Gajurichhap and Gauthale is acidic while in other three villages it is very acidic range. In all the villages, except Ange and Chankhubensi, the pH at the surface layer is highest and this successively decreases in lower layers. In Ange and Chankhubensi, the change pH along the soil profile show a reverse pattern and this is probably due to the excessive leaching of the basic cations from the top layer. The surface layers in these villages have relatively lower per cent of clay fraction, which facilitates the rapid infiltration of the basic cations.

Table 1. Analytical results of soil samples collected from various research plots

Village	Soil Depth (cm)	pH	Exch. K (me)	Total N (%)	Organic C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	Texture
Gajuri	0-20	6.11	0.15	0.12	1.10	6.51	39.80	42.80	17.40	loam
	20-40	6.08	0.16	0.10	0.91	4.04	37.80	43.40	18.80	loam
	40-100	6.10	0.18	0.08	0.71	3.34	36.80	43.80	19.40	loam
	100-200	6.08	0.18	0.09	0.77	3.17	35.78	43.55	20.67	loam
Gauthale	0-20	5.95	0.27	0.13	1.21	12.31	26.60	47.30	26.10	Clay loam
	20-40	5.93	0.21	0.11	1.04	10.44	26.20	47.40	26.40	Clay loam
	40-100	5.89	0.22	0.11	1.04	9.70	24.20	47.40	28.40	Clay loam
	100-200	5.84	0.28	0.11	0.94	13.08	26.40	43.20	30.40	Clay loam
Tawari	0-20	5.54	0.33	0.16	1.84	10.01	25.20	57.00	17.80	Silt loam
	20-40	5.50	0.14	0.12	1.25	5.74	25.00	56.60	18.40	Silt loam
	40-100	5.53	0.12	0.09	0.94	5.18	24.00	55.80	20.20	Silt loam
	100-200	5.46	0.11	0.07	0.75	3.42	24.75	53.50	21.75	Silt loam
Ange	0-20	5.27	0.28	0.08	0.87	56.52	68.10	21.90	10.00	Sandy loam
	20-40	5.31	0.23	0.09	0.67	46.71	67.00	22.60	10.40	Sandy loam
	40-100	5.41	0.25	0.05	0.63	47.06	67.30	20.50	12.20	Sandy loam
	100-200	5.48	0.29	0.04	0.55	50.88	61.00	24.44	14.55	Sandy loam
Chankhu	0-20	4.65	0.32	0.10	1.16	83.65	38.40	37.60	14.00	loam
	20-40	5.19	0.26	0.08	0.92	74.71	38.22	43.11	18.67	loam
	40-100	5.24	0.20	0.07	0.78	38.45	40.22	42.33	17.44	loam

	100-200	5.34	0.22	0.05	0.63	43.89	43.25	38.62	18.12	loam

The results of Anova analysis (Table 2) show that all the five villages vary significantly in their nutrient contents. In all the villages the nutrients were found to be highest in the soils at 0-20 cm depth. The concentration of all the nutrients decreased gradually in 20-40 cm, 40-100 and 100-200 cm depths.

Table 2: Analysis of variance of the soil properties

Soil properties	Source of variation	F-ratio	Sig. level
PH	Villages	28.680	0.0000
	Depth	0.922	0.4597
Potassium (me/100g)	"	3.207	0.0523
	"	2.310	0.1282
Total Nitrogen (%)	"	13.939	0.0002
		14.369	0.0003
Total Organic Carbon (%)	"	6.677	0.0046
		10.479	0.0011
Available Phosphorus (ppm)	"	31.380	0.0000
		1.893	0.1847
Sand (%)	"	234.489	0.0000
		0.384	0.7667
Silt (%)	"	177.142	0.0000
		1.051	0.4058
Clay (%)	"	159.893	0.0000
		17.236	0.0001

In the surface layer (0-20 cm), the highest concentration of all the nutrients except available phosphorus is present in Tawari. It is followed by Gauthale, Chankhubensi, Ange and Gajurichhap for the second, third, fourth and last position respectively in the overall ranking based on the nutrients present in that depth.

Similarly, in the second layer (20-40 cm) Chankhubensi has the highest concentration of exchangeable potassium and available phosphorus while the concentration of nitrogen and organic carbon fall in the 5th and 3rd position. In the same depth, Tawari has the highest concentration of nitrogen and organic carbon. The amount of other nutrients in this village lies in the 4th and 5th position. In the overall ranking Chankhubensi secured the first place. It is followed by Tawari, Gauthale, Ange and Gajurichhap for second, third, fourth and fifth places.

The concentration of total nitrogen and organic carbon in the third layer (40-100 cm) is highest in Gauthale. The other nutrients present in this village secured second and third positions. Likewise the concentration of exchangeable potassium and available phosphorus is maximum in Ange. The contents of nitrogen and organic carbon in this village lie in fourth position. The overall grading of villages based on the content of nutrients indicate that Gauthale holds the top rank. Ange, Tawari, Chankhubensi and Gajurichhap proceed it for second, third, fourth and fifth rank.

In the bottom layer (100-200 cm) Gauthale with the highest concentrations of nitrogen and organic carbon occupies the first rank and is succeeded by Ange, Gajurichhap, Chankhubensi and Tawari for second, third, fourth and fifth ranks.

4.7. Survey on fertilizer use

Appendix 3 shows different doses of fertilizers applied by the farmers in five villages. Farmers in the study areas have been using five different types of chemical fertilizers viz. urea, ammonium sulphate, ammonium phosphate, triple super-phosphate, diammonium phosphate and compost for maintaining the soil fertility in their fields. The compost is generally made from the animal bedding and manure. Farmers use these fertilizers primarily for the crops and vegetables. Nevertheless, trees planted on the terrace risers can also benefit from the added fertilizers. Urea and compost, of all these fertilizers, appear to be most favoured and common to all the farmers. Only few farmers use the other phosphate fertilizers. The average urea and compost application rates are given in the Table 3. Tawari has the highest application dose of urea (15.8 Kg/ropani) and compost (29.5 dokos/ropani) while Gauthale and Gajurichhap have lowest dose of urea (3.17 Kg/ropani) and compost (20.3 dokos/ropani) respectively.

Table 3: Average fertilizer application rate in five villages

Fertilizer	VILLAGE				
	Gajurichhap	Gauthale	Tawari	Ange	Chankhubesi
Urea (Kg/ropani)	4.12	3.17	15.8	7.2	13.5
Compost (Doko/ropani)	20.3	22.9	29.5	22.4	26.0

There is significant variation in the dose of compost and urea applied by the farmers across the villages (Table 4). The discrepancy in the use of fertilizers may have occurred due to difference in the socio-economic status and access to fertilizer market. There is very little difference, but insignificant, in the frequency of application. This difference is seen in case chemical fertilizer application at Gajurichhap village and Tawari. The other villages have similar urea and compost application frequency. The highest frequency of application is 3 times and lowest is once per year. The majority of farmers seem to prefer to apply fertilizers once a year.

Table 4: Analysis of Variance of the fertilizer application

Fertilizer	Source of variation	F-ratio	Sig. level
Urea	Village	19.473	0.0000
Compost	Village	2.864	0.0341

The amount of urea applied by the farmers ranged from 3.17 kg/ropani to 15.8 kg/ropani. Chankhubensi applied highest amount while Gauthale added lowest amount of urea. In the same fashion the quantity of compost added by the farmers varied from 20.3 dokos to 29.5 dokos per ropani. The highest amount of urea applied by the farmers was in Tawari whereas the lowest was in Gajurichhap.

4.8. Plant survival and growth

Table 5 presents the survival percentage of three fodder seedlings. Ipil-Ipil has the highest survival (84%). Kimbu (82%) and Badahar (78%) follow it. Of all the villages Gajurichhap has the highest survival of Ipil while Chankhubensi had the lowest. Gauthale Tawari and Ange occupy second, third and forth respectively for Ipil survival. In case of Badahar's survival, Gauthale (78%) was on the top. It is succeeded by Gajurichhap, Chankhubensi and Ange for the second, third and fourth place. The survival percent of Kimbu is found to be highest in Tawari (82%). Chankhubensi (54%) has the lowest per cent of survival of Kimbu. Ipil shows highly significant correlation with survival percentage of Badahar, however, no such correlation is seen between Kimbu and Ipil or Badahar or Kimbu.

Table 5: Average survival and growth of different species in five villages

SPECIES	VILLAGE

		Gajurichhap	Gauthale	Tawari	Ange	Chankhubesi
Survival	Badahar	73.7	78.1	-	50.0	56.2
	Ipil-Ipil	84.8	71.7	50.4	45.8	45.1
	Kimbu	56.2	77.3	82.4	64	54.8
Growth	Badahar	7.3	2.3	-	9.8	16.1
	Ipil-Ipil	55.2	29.1	24.0	22.2	23.7
	Kimbu	28.5	10.1	17.5	27.9	41.7

The height and growth of the three species are given in the Table 5. The growth of Badahar range from 2.3 cm to 16.1 cm. Chankhubensi had the tallest Badahar while Gauthale had the shortest. The height of Ipil varied from 22.2 cm to 55.2 cm. Ipil at Gajurichhap had the highest growth whereas at Ange it was the lowest. Likewise the growth of Kimbu ranged from 10.1 cm at Gauthale to 41.7 cm at Chankhubensi.

There is a significant difference in the survival percentage of Ipil-Ipil in five villages (Table 6). The difference in the survival of Badahar and Kimbu were not significant, however, were quite close to be able to be significant. The variation in height growth of Ipil across the villages was prominent (Table 6). Kimbu and Badahar had insignificant difference in growth in five villages

Table 6: Analysis of Variance of plant survival and growth

Species		Source of variation	F-ratio	Sig. level
Survival	Badahar	Villages	2.526	0.073
	Ipil-Ipil	"	3.921	0.008
	Kimbu	"	2.338	0.070
Growth	Badahar	"	1.352	0.276
	Ipil-Ipil	"	4.028	0.016
	Kimbu	"	2.736	0.060

4.9 Soil Properties, Fertilizer and Plant Survival and Growth

The correlation matrix between soil properties and plant survival and growth is given in the Table 7. In this correlation study the soil properties of 0-20 cm depth for Ipil, and 100-200 cm depth for Badahar and Kimbu have been taken into account as these seedlings were planted at those depths of the terrace risers. The survival and growth of Ipil is significantly correlated with pH of soil. The survival of Badahar, although not significantly different, shows correlation with pH, organic carbon, and nitrogen percentage of the soil. Surprisingly available phosphorus and exchangeable potassium have shown negative effect on the survival and growth of the seedlings. This may be because the sites with higher phosphorus and potassium had insufficient supply of other essential nutrients resulting into poor performance of plant.

Table 7: Correlation matrix for survival and growth of fodder sp. versus soil properties

Soil Properties	Survival and Growth of Ipil			
	Survival (%)		Growth (cm)	
	r	p	r	p

pH	0.87	0.05	0.71	0.28
Exch. K	-0.87	0.05	-0.96	0.03
Total N	0.31	0.60	0.53	0.46
Organic C	0.12	0.84	0.21	0.78
Available P	0.66	0.17	-0.71	0.28
Sand	-0.32	0.60	-0.29	0.71
Silt	0.31	0.61	0.48	0.52
Clay	0.59	0.29	0.24	0.76

The correlation between compost addition and total organic carbon and exchangeable potassium content in the surface layer of soil in five villages is quite significant. Other nutrients like nitrogen and phosphorus had poor correlation with the application of compost (Table 8). Similarly, the addition of urea had no correlation with total nitrogen in the upper layer of soil. The lack of proper correlation between soil nutrient content and application of the chemical and organic fertilizers may be due to inadequate and inappropriate application technique.

Table 8: Correlation matrix for fertilizer application verses soil properties

Fertilizer	Soil properties									
	pH		Potassium		Nitrogen		Carbon		Phosphorus	
	r	p	r	p	r	p	r	p	r	p
Urea	-0.67	0.22	0.74	0.15	0.28	0.64	0.64	0.24	0.36	0.55
Compost	-0.46	0.43	0.83	0.08	0.54	0.35	0.82	0.08	0.11	0.85

The addition of compost by the farmers on the agricultural crops does not seem to have marked effect on the survival and growth of planted seedlings. Likewise, the effects of urea on in the growth and survival of the seedlings except Badahar, also appear to be insignificant (Table 9). This may be either due to total consumption of the added fertilizers by the crop, so that there was very little left for tree crops or the amount added was insufficient. One other possibility is the improper management of the fertilizers.

Table 9: Correlation matrix for survival and growth of fodder sp. versus fertilizer application

Species		Fertilizer			
		Urea		Compost	
		r	p	r	p
Survival	Ipil	-0.74	0.15	-0.64	0.24
	Badahar	-0.71	0.28	-0.44	0.56
	Kimbu	0.17	0.78	0.53	0.36
Growth	Ipil	-0.55	0.33	-0.64	0.25
	Badahar	0.95	0.04	0.65	0.35
	Kimbu	0.33	0.59	-0.052	0.93

5. Discussion

There is a considerable difference in the site characteristic such as altitude, aspect and slope across the villages. These variations appear to have occurred due to lack of farmers in the participatory agroforestry research in the similar site condition. Most of the farmers in the study area have small land holding which provided very little room for the adjustment. The site variation may affect the survival and growth of the seedlings. Studies have shown that *A. lakoocha* (Jackson, 1994) and *L. diversifolia* (Hughs, 1998) are sensitive to the frost. These species may suffer to some extent from this problem at Tawari and Ange, which are located at higher altitude, and have occasional frost. Similarly A. lakoocha and M. alba have been reported to have poor growth at higher altitude (Jackson, 1994).

The annual precipitation pattern of the five study areas, based on the meteorological data obtained available from the nearest station at Kathmandu and Chautara appears to be quite similar. These sites fall in the area with the dry period ranging from October to March. The evapotranspiration in this duration exceeds the precipitation (Jackson, 1994) and creates pronounced moisture stress in these periods. The limited available moisture, therefore, may restrict the performance of the plants. The site such as Ange with low organic carbon content and coarse texture may suffer heavily from the shortage of moisture. Other sites like Tawari, Chankhubensi and Gajurichhap with medium texture and with moderate level of organic carbon may be competitively better of with more moisture holding capacity. These sites have relatively better survival and growth (Table 5). The seasonal shortage of the moisture can be overcome by applying proper moisture conservation measures and water harvesting technique. The removal of the competing grasses around the root of the seedlings can to some extent conserve the moisture. Likewise the moisture can also be conserved by covering the soil with straws and dead grasses surrounding the base of the seedling.

The soil physical characteristics such as depth, drainage and profile distributions among the sites are quite similar. The soils are generally red and weathered. The difference in textures of the soil, however, is prominent. The soils at Ange with very coarse texture will provide better drainage, air supply and environment for the root growth. While the soils at Gajurichhap, Chankhubensi and Tawari with medium texture will be reasonably good in terms of these characteristics. In contrast, the soils at Gauthale are likely to be little less suitable for these purposes.

The soils in all the research sites are invariably acidic. The low pH may have resulted due to low organic matter content and loss of large amount of the basic cations down the soil profile through leaching. Shah and Schreier (1992) and Baral, et al., (1999) in their separate studies on red soils have also reported low soil pH. The soil nutrients viz. total organic carbon, total nitrogen, available phosphorus and exchangeable potassium vary significantly among the sites. The contents of some nutrients within a plot also differ. The variation in the nutrient contents may be partly due to inherent soil characteristic and partly due to difference in dose of fertilizer applied by the farmers. The content of the nutrient elements on the surface are generally higher as this layer receives the fertilizer and composts first and it remains there for longer periods. The difference in the concentration of these nutrients in the subsequent layer occurs due to their leaching down the profile. The concentration of available phosphours is generally low in the red soils (Shah and Scheirer, 1992 and Baral, et al., 1999), however, it has been found astonishingly high in some plots in the present study. It is likely that the farmers have been adding very high doses of phosphate fertilizer for intensive cultivation. The presence of healthy vegetable crops such as cauliflower, potato and beans in the field during the visit is an indication of this. Likewise, the level of exchangeable potassium in some plots is unusually high. This can be attributed to the application of fertilizer, manure and compost. It may also be partly due to the presence of potassium bearing parent materials in the soil.

The fertility of soil is replenished annually by the farmers by applying organic and inorganic fertilizers. Considering the nature of the soils it appears essential to apply additional fertilizer inputs on regular basis if better crop production is desired. The application of compost and urea is a common practice of all the farmers in the villages. Only few farmers have been adding other fertilizers viz., ammonium sulphate, ammonium phosphate, triple super-phosphate, diammonium phosphate. The lack of use of these fertilizers among other farmers may be due its unavailability and inaccessibility. This can also be due to the lack of knowledge of those fertilizers with the farmers. The dose of compost and urea applied by the farmers in the field is not uniform. The difference is probably due to discrepancy in the socio-economic status of the farmers as the farmers with better economic condition and larger family can afford to apply higher amount of compost and fertilizer deemed essential for balanced nutritional supply to the crop.

There is no relation between concentration of nutrients such as total organic carbon and nitrogen in the soil and the amount of compost and fertilizers applied annually by the farmers. The variation in the loss of added nutrients through leaching or surface runoff or volatilization in the research sites appears to be responsible for this. It may also be the result of the variation in the quality of fertilizer added. The quality of the compost and fertilizer may have dropped due to inappropriate method used for its preparation and application. The disagreement between nutrient added and fertility status may have resulted due to insufficient amount of the compost and fertilizer added to the soil.

The nutrient status of the soil in the majority of the cases is medium for tree growth (Appendix 5). The pH of soil has considerable effect on the survival and growth of plants. Gajurichhap and Gauthale, having pH 6.11 and 5.95 have higher survival percentage of Ipil than in other three sites with lower pH. It indicates that Ipil grows better at pH near to neutral. The present result agrees with study carried out with a wider range of species and seed sources which has reported the poor survival and low acid soil tolerance of Leucaena species on several sites in Asia (Khoa et al., 1997; Castillo et al., 1997). However, the finding differs from the results of Hutton (1981,1990,1995) and Oakes and Foy (1984) and Holden et al., (1988) that *L. diversifolia* exhibit some acidic soil tolerance. Similarly Badahar shows lower survival at Chankhubensi (56%) and Ange (50%) than at Gauthale (78%) and Gajurichhap (74%). This may also be due to susceptibility of Badahar to strongly acidic soil (MPTS, 1990). The higher survival of Badahar in higher pH agrees with the results of Napier and Parajuli (1987) in which 100% survival of Badahar has been reported at soil pH 6.3. Kimbu being susceptible only to strongly alkaline soil (MPTS, 1990) variation in pH of the study plots which are all acidic do not show any variation in survival with the difference in soil reaction.

The content of nitrogen, organic carbon, phosphorus and potassium in the soil appears to have no effect on the survival of Ipil, although it is a nutrient demanding species (Jackson, 1994; Cobbina, et al., 1989). This is probably due to occurrence of the marginal level of nutrients in sites having suitable pH range for Ipil. In other sites with relatively better nutrient stautus, the unfavorable soil reaction and loss of nutrient through leaching might have hindered the availability of the nutrients. Badahar, which is a high nutrient demanding species, tends to show correlation with the amount of nitrogen, organic carbon in spite of its susceptibility to the strong acidity. This is probably due to relatively higher pH of the soil supporting Badahar than that of Ipil. As a result nutrients became more available and showed better relation with survival. Kimbu appear to be unaffected by the variation in the nutrient content, except organic carbon. This is perhaps due to its low nutrient requirement and its sensitivity to physical condition such as depth and drainage of (Jackson, 1994; Singh, 1982) the site (Appendix 5).

The relation between application of fertilizers and growth and survival of the seedling is quite poor. One probable reason for this may be the low pH, which may have restricted availability of the nutrients to the plant. The effect of added fertilizer may also have been obstructed due to the lack of adequate level of all the essential nutrients as most of the farmers applied urea only. The application of lower dose of poor quality fertilizer in the inappropriate time could be another possible cause for the poor correlation.

The nutrient status of soil for agricultural crop varies of lower to medium level depending up on the type of crop to be cultivated. The existing soil pH of Tawari, Ange and Chankhubesi needs to be raised for changing the pH to suitable range for growing maize and wheat, however, they are quite suitable for potato, millet, oat. The pH of Gajurichhap is quite suitable for maize, wheat, barley, oat, rice and millet (Table 10), however, it will be better if the pH is slightly raised. The pH at Gauthale is marginal for maize, wheat but is suitable for millet and oat. Like in the previous case it will also require some increase in pH. The recommended doses of lime for different sites and crops are given in the Table 10.

The amount of urea applied by the farmers at Tawari and Chankhubesi are higher than the recommended dose for non-irrigated land for maize, rice, wheat, millet and mustard, while it is at recommended level at Ange. In contrast the level of urea added by the framers at Gajurichhap and Gauthale is about half the recommended dose. The application of compost by all the farmers in the five villages fall in the range prescribed for the cops. It is, however, less for potato and vegetables, which requires 60 dokos/ ropani.

Table 10: Lime and Fertilizer recommendations for various crops at five villages

Village	Crop	Inorganic fertilizer (Kg/ropani)			Compost (Doko/ropani)	Lime (Kg/ropani)
		Urea	TSP	M.Potash		
Gajurichhap	Rice	3.30	2.10	0.85	20	
	Wheat	2.75	5.25	0.85	"	78
	Maize(winter)	4.95	4.72	1.92	"	"
	Kauli/others	5.50	8.40	2.55	60	"
	spinach	3.85	4.20	2.97	"	"
Gauthale	Rice	3.30	1.57	0.42	20	
	Wheat	2.75	2.62	0.42	"	146
	Maize(winter)	4.95	2.37	0.95	"	"
	Kauli/others	5.50	4.20	1.27	60	"
	Vegetable	3.85	2.10	0.65	"	"
Tawari	Rice	3.30	1.57	0.42	20	
	Wheat	2.75	2.62	0.42	"	200
	Maize(winter)	4.95	2.37	0.95	"	"
	Millet	3.30	2.10	1.27	60	"
	Vegetable	3.85	4.20	0.65	"	"
Ange	Rice	6.60	NR	0.42	20	
	Wheat	5.50	"	0.42	"	150
	Maize(winter)	9.90	"	0.95	"	"
	Millet	6.60	"	0.65	60	"
	Kauli/others	11.0	"	0.65	"	"
Chankhubesi	Rice	6.60	"	0.42	20	
	Wheat	5.50	"	0.42	"	280
	Maize(winter)	9.90	"	0.95	"	"
	Kauli/others	11.0	"	0.65	60	"
	Potato	7.70	"	0.85	"	120

The level of nitrogen is medium at Gajuri, Gauthale and Tawari while it is low at Ange and Chankhubensi. The amount of urea applied by the farmers at Tawari and Chankhubesi are higher than the recommended dose for non-irrigated land for maize, rice, wheat, millet and mustard, while it is at recommended level at Ange. In contrast the level of urea added by the framers at Gajurichhap and Gauthale is about half the recommended dose. The application of compost by all the farmers in the five villages fall in the range prescribed for the cops. It is, however, less for potato and vegetables, which requires 60 dokos/ ropani.

6. Conclusions

The physical characteristics of soil, with some variation in texture and stone content in all the research sites, are by and large the same. The chemical properties, however, vary significantly across the five villages. According to the nutrient content in surface layer the villages lie in the order of Tawari > Gauthale > Chankhubesi > Ange > Gajurichhap. In spite of the differences in nutrient status, the sites have great potentiality for the fodder and crop production if proper moisture and nutrient management is applied. The shortage of moisture during dry period can be improved through water harvesting. Addition of recommended doses of lime, compost and fertilizers could enhance the availability of nutrients in the soil.

Application of urea and compost in the agricultural land is a common practice. There is a significant variation in the quantity of fertilizers applied by the farmers among the five villages. The fertilizers added for agricultural crops, however, do not appear to have contributed in the growth and survival of the tree seedlings.

There is a significant difference in the height and growth of Ipil across the villages. The survival and growth of Badahar and Kimbu, however, did not vary significantly among the five villages. The soil reaction has significant effect on the survival of Ipil and Badahar. The differences in survival and growth of the Ipil are due to variability in pH of soil. Likewise the survival of Badahar, although insignificant, tends to show correlation with nitrogen and organic carbon.

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Appendix 1: Site and profile description of Gajurichhap village

Elevation	Aspect	Slope	Pit No.	Depth	Profile description
650 m	S/SE	31O	1	0-20	Yellowish red 5 YR 5/ 6; loam; angular blocky structure; friable, sticky consistence; medium, few stones; live roots present.
				20-40	Yellowish red 5 YR 4 / 8; loam; angular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 8; loam; angular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; loam; angular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
750 m	N	21O	2	0-20	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				20-40	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Yellowish red 5 YR 4 /8; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
650 m	N	27O	3	0-20	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence;, medium, common stones; live roots present
				100-120	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, common stones; live roots present
680 m	NE	25O	4	0-20	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100+	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots absent
690 m	E	27O	5	0-20	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-120	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
690 m	E	27O	6	0-20	Reddish brown 5 YR 4 / 4; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-120	Yellowish red 5 YR 4 / 8; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few, stones; live roots present
730 m	E	31O	7	0-20	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-120	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
700 m	EN	31O	8	0-20	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium , few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium , few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-120	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
790 m	E	40O	9	0-20	Dark brown 5 YR 3 / 3; loam; subangular blocky structure; loose, sticky (moist) consistence; small, few stones; live roots present
				20-40	Dark brown 5 YR 3 / 3; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Dark brown 5 YR 3 / 3; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
750 m	E	30O	10	0-20	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-120	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots absent

Appendix 1: Site and profile description of Gauthale village

Elevation	Aspect	Slope	Pit No.	Depth	Profile description
520 m	S/SE	27O	11	0-20	Yellowish red 5 YR 4/ 6; clay loam; subangular blocky structure; friable, sticky consistence; large, common stones; live roots present.
				20-40	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
600 m	N	35O	12	0-20	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
750 m	NW	21O	13	0-20	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Yellowish red 5 YR 4 / 8; clay loam/ silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Yellowish red 5 YR 4 /6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish brown 10 YR 5 / 8; clay / clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
800 m	NW	25O	14	0-20	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots absent
700 m	S	32	15	0-20	Strong brown 7.5 YR 5 / 6; loam / silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 5 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Yellowish red 5 YR 5 / 6; clay loam / silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Red 2.5 YR 4 / 6; silt clay / silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
675 m	S	40O	16	0-20	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence;, large, common stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Reddish brown 5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, common, stones; live roots present
650 m	S	35O	17	0-20	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish red 5 YR 4 / 8; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
590 m	S	35O	18	0-20	Reddish brown 5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				20-40	Reddish brown 5 YR 4 / 4; loam; subangular blocky structure; friable, sticky (moist) consistence; large , few stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				100-200	Dark reddish brown 5 YR 3 / 4; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
790 m	E	40O	19	0-20	Strong brown 7.5 YR 5 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present

750 m	E	30O	20	0-20	Yellowish red 5 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 5 / 6; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots absent

Appendix 1: Site and profile description of Tawari village

Elevation	Aspect	Slope	Pit No.	Depth	Profile description
1780 m	NW	35O	21	0-20	Dark yellowish brown 10 YR 4/ 4; silt loam / loam; subangular blocky structure; friable, sticky consistence;, live roots present.
				20-40	Yellowish brown 10 YR 5/6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Yellowish brown 10 YR 5/6; silt clay loam; angular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish brown 10 YR 5/ 6; silt loam; angular blocky structure; friable, sticky (moist) consistence; live roots present
600 m	N	35O	22	0-20	Dark yellowish brown 10 YR 4/ 4 ; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
1750 m	NE	30O	23	0-20	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 8; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				100-200	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
1700 m	NE	30O	24	0-20	Yellowish brown 10 YR 5 / 6; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 8; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				40-100	Strong brown 7 YR 5 / 6; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
				100-120	Strong brown 7 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, many stones; live roots present
1650 m	N	30O	25	0-20	Dark yellowish brown 10 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Dark yellowish brown 10 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; abundant live roots present
				40-100	Dark yellowish brown 10 YR 3 / 4; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; abundant live roots present
				100-200	Dark yellowish brown 10 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; abundant live roots present
1700 m	E	30O	26	0-20	Dark yellowish brown 10 YR 4 / 4; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
1840 m	E	22O	27	0-20	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; few, small stones; live roots present
				20-40	Brown/ Dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; few, small stones; live roots present
				40-100	Brown/ dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; few, small stones; live roots present
1800 m	E	26O	28	0-20	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Brown 7.5 YR 5 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-80	Brown/ dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				80-100	Yellowish red 5 YR 4 / 8; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1750 m	S	42O	29	0-20	Brown/ dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, many stones; live roots present
				20-40	Brown/ dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, many stones; live roots present
				40-100	Brown/ dark brown 7.5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, many stones; live roots present

				100-200	Brown 7.5 YR 5 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, many stones; live roots present
1820 m	SE	28O	30	0-20	Dark yellowish brown 10 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Yellowish brown 10 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots absent

Appendix 1: Site and profile description of Ange village

Elevation	Aspect	Slope	Pit No.	Depth	Description
1100 m	W	30O	31	0-20	Dark yellowish brown 10 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present.
				20-40	Brown / dark brown 10 YR 4 / 3; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Brown / dark brown 10 YR 4 / 3; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Brown / dark brown 10 YR 4 / 3; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1770 m	WS	27O	32	0-20	Yellowish brown 10 YR 5 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-150	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1150 m	W	17O	33	0-20	Very dark brown 10 YR 3 / 3; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Dark yellowish brown 10 YR 3 / 4; Sandy clay loam / loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1200 m	SW	30O	34	0-20	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Yellowish brown 10 YR 5 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish brown 10 YR 5 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1330 m	W	32O	35	0-20	Brown 7.5 YR 5 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Brown / dark brown 7.5 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Brown / dark brown 7.5 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Dark reddish brown 5 YR 3 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
1300 m	N	33O	36	0-20	Yellowish brown 10 YR 5 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
1200 m	W	20O	37	0-20	Pale brown 10 YR 6 / 3; Sandy loam / loamy sand; round structureless; powdery, loose (moist) consistence; small, few stones present
				20-40	Pale brown 10 YR 6 / 3; Sandy loam / loamy sand; round structureless; powdery, loose (moist) consistence; small, few stones present
				40-100	Pale brown 10 YR 6 / 3; Sandy loam / loamy sand; round structureless; powdery, loose (moist) consistence; small, few stones present
				100-200	Pale brown 10 YR 6 / 3; Sandy loam / loamy sand; round structureless; powdery, loose (moist) consistence; small, few stones present
1130 m	SW	34O	38	0-20	Red 2.5 YR 5 / 6; loamy sand; round structureless; powdery, loose (moist) consistence; small, few stones present
				20-40	Reddish brown 2.5 YR 4 / 4; sandy loam; round structureless; powdery, loose (moist) consistence; small, few stones present

				40-100	Reddish brown 2.5 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
1100 m	SW	30O	39	0-20	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, non-sticky (moist) consistence; live roots present
				20-40	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, non-sticky (moist) consistence; live roots present
				40-100	Dark yellowish brown 10 YR 3 / 4; Sandy loam; subangular blocky structure; friable, non-sticky (moist) consistence; live roots present
				100-200	Dark yellowish brown 10 YR 3 / 4; Sandy loam; subangular blocky structure; friable, non-sticky (moist) consistence; live roots present
1100 m	SW	30O	40	0-20	Dark yellowish brown 10 YR 4 / 4; Sandy loam; subangular blocky structure; friable, non-sticky (moist) consistence; live roots present
				20-40	Brown / dark brown 7.5 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Brown / dark brown 7.5 YR 4 / 4; sandy loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Brown / dark brown 7.5 YR 4 / 4; sandy clay loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present

Appendix 1: Site and profile description of Chankhubensi village

Elevation	Aspect	Slope	Pit No.	Depth	Description
1350 m	N	15O	41	0-20	Yellowish red 5 YR 4/ 6; clay loam; subangular blocky structure; friable, sticky consistence; large, common stones; live roots present.
				20-40	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
600 m	N	35O	12	0-20	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; medium, few stones; live roots present
750 m	NW	21O	13	0-20	Yellowish red 5 YR 4 / 8; clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Yellowish red 5 YR 4 / 8; clay loam/ silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				40-100	Yellowish red 5 YR 4 /6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish brown 10 YR 5 / 8; clay / clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
800 m	NW	25O	14	0-20	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				40-100	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; loam; round crumb structure; powdery lose (moist) consistence; medium, few stones; live roots absent
700 m	S	32	15	0-20	Strong brown 7.5 YR 5 / 6; loam / silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 5 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				40-100	Yellowish red 5 YR 5 / 6; clay loam / silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Red 2.5 YR 4 / 6; silt clay / silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
675 m	S	40O	16	0-20	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				20-40	Yellowish red 5 YR 4 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence;, large, common stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; loam; subangular blocky structure; friable, sticky (moist) consistence; large, common stones; live roots present
				100-200	Reddish brown 5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, common, stones; live roots present
650 m	S	35O	17	0-20	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				20-40	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present

				40-100	Yellowish red 5 YR 5 / 6; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
				100-200	Yellowish red 5 YR 4 / 8; silt clay loam; subangular blocky structure; friable, sticky (moist) consistence; live roots present
590 m	S	35O	18	0-20	Reddish brown 5 YR 4 / 4; silt loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				20-40	Reddish brown 5 YR 4 / 4; loam; subangular blocky structure; friable, sticky (moist) consistence; large , few stones; live roots present
				40-100	Reddish brown 5 YR 4 / 4; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				100-200	Dark reddish brown 5 YR 3 / 4; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
790 m	E	40O	19	0-20	Strong brown 7.5 YR 5 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; large, few stones; live roots present
				20-40	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish brown 10 YR 5 / 8; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
750 m	E	30O	20	0-20	Yellowish red 5 YR 5 / 6; silt loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				20-40	Yellowish red 5 YR 5 / 6; silt loam / loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				40-100	Yellowish red 5 YR 5 / 6; loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots present
				100-200	Yellowish red 5 YR 4 / 6; clay loam; subangular blocky structure; friable, sticky (moist) consistence; small, few stones; live roots absent

Appendix 2:Analytical results of the soils collected from Gajurichhap village

Field No	Location	Pit No.	Lab No.	Soil depth	pH	K (me)	Total N (%)	Org C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	TEXTURE
1	Top Bahadur	1	7050	0-20	5.83	0.10	0.08	0.66	2.79	48	40	12	LOAM
2	Dhading, Gajuri	1	7051	20-40	5.81	0.05	0.06	0.47	1.39	48	38	14	LOAM
3	"	1	7052	40-100	5.81	0.04	0.06	0.43	0.70	42	42	16	LOAM
4	"	1	7053	100-200	5.71	0.10	0.06	0.46	0.70	36	42	22	LOAM
5	Eak Bahadur	2	7054	0-20	5.83	0.30	0.10	1.12	13.14	34	44	22	LOAM
6	Dhading, Gajuri	2	7055	20-40	5.72	0.20	0.13	1.22	10.93	28	48	24	LOAM
7	"	2	7056	40-100	5.86	0.40	0.13	1.22	10.47	30	48	22	LOAM
8	"	2	7057	100-200	5.81	0.40	0.16	1.51	11.28	30	46	24	LOAM
9	Sumitra Magar	3	7058	0-20	5.95	0.10	0.15	1.26	2.33	42	40	18	LOAM
10	Dhading, Gajuri	3	7059	20-40	5.9	0.10	0.13	1.14	1.63	40	42	18	LOAM
11	"	3	7060	40-100	5.95	0.08	0.10	0.89	0.81	40	42	18	LOAM
12	"	3	7061	100-200	6.02	0.07	0.08	0.62	0.70	46	38	16	LOAM
13	Amar Bahadur	4	7062	0-20	6.37	0.11	0.08	0.95	3.37	44	42	14	LOAM
14	Dhading, Gajuri	4	7063	20-40	6.37	0.06	0.05	0.66	2.44	44	42	14	LOAM
15	"	4	7064	40-100	6.39	0.05	0.04	0.52	2.44	42	42	16	LOAM
16	"	4	7065	100-200	6.42	0.05	0.03	0.40	2.91	44	42	14	LOAM
17	Ganesh Bahadur	5	7066	0-20	6.39	0.08	0.06	0.79	6.98	42	44	14	LOAM
18	Dhading, Gajuri	5	7067	20-40	6.39	0.06	0.07	0.74	3.72	44	42	14	LOAM
19	"	5	7068	40-100	6.43	0.06	0.03	0.44	2.21	40	46	14	LOAM
20	"	5	7069	100-200	6.43	0.06	0.06	0.59	2.33	42	44	14	LOAM
21	Dhana Bahadur	6	7070	0-20	6.3	0.23	0.15	1.51	15.23	40	46	14	LOAM
22	Dhading, Gajuri	6	7071	20-40	6.35	0.28	0.12	1.13	6.28	40	44	16	LOAM
23	"	6	7072	40-100	6.35	0.37	0.11	0.91	4.54	36	44	20	LOAM
24	"	6	7073	100-200	6.35	0.54	0.12	1.13	5.35	34	54	12	SILT LOAM
25	Lila Bahadur	7	7074	0-20	6.48	0.08	0.07	0.65	2.09	46	42	12	LOAM

26	Dading, Gajuri	7	7075	20-40	6.48	0.40	0.05	0.41	0.7	46	40	14	LOAM
27	"	7	7076	40-100	6.42	0.40	0.04	0.30	0.47	44	40	16	LOAM
28	"	7	7077	100-200	6.42	0.06	0.04	0.24	0.12	40	36	24	LOAM
29	Budhi B Koirala	8	7078	0-20	6.12	0.21	0.18	1.17	2.21	34	36	30	CLAY LOAM
30	Dhading, Gajuri	8	7079	20-40	5.92	0.19	0.15	1.05	1.98	24	44	32	CLAY LOAM
31	"	8	7080	40-100	5.86	0.18	0.14	1.03	3.19	22	44	34	CLAY LOAM
32	"	8	7081	100-200	5.76	0.18	0.14	1.04	2.64	24	44	32	CLAY LOAM
33	Hari Bahadur	9	7082	0-20	6.07	0.14	0.15	1.47	13.32	38	46	16	LOAM
34	Dhading, Gajuri	9	7083	20-40	5.95	0.11	0.15	1.49	8.92	34	48	18	LOAM
35	"	9	7084	40-100	6.03	0.10	0.08	0.7	8.59	40	46	14	LOAM
36	Man Bahadur	10	7085	0-20	5.8	0.18	0.16	1.38	3.63	30	48	22	LOAM
37	Dhading, Gajuri	10	7086	20-40	5.93	0.14	0.14	0.82	2.42	30	46	24	LOAM
38	"	10	7087	40-100	5.9	0.15	0.12	0.67	0	32	44	24	LOAM
39	"	10	7088	100-200	5.83	0.18	0.11	0.91	2.53	26	46	28	CLAY LOAM

Table: Analytical results of the soils collected from Gauthale village

Field No	Location	Pit No.	Lab No.	Soil depth	pH	K (me)	Total N (%)	Org C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	TEXTURE
40	Dhana Bahadur	11	7089	0-20	6.01	0.57	0.11	1.51	5.94	26	46	28	CLAY LOAM
41	Dhading, Gauthale	11	7090	20-40	5.72	0.32	0.15	1.43	4.73	22	46	32	CLAY LOAM
42	"	11	7091	40-100	5.64	0.33	0.15	1.47	5.17	18	46	36	SILTY CLAY LOAM
43	"	11	7092	100-200	5.47	0.25	0.12	1	3.41	20	42	38	CLAY LOAM/SILTY CLAY LOAM
44	Bhim Bahadur	12	7093	20	5.89	0.36	0.13	1.32	3.74	30	42	28	CLAY LOAM
45	Dhading, Gauthal	12	7094	40	5.99	0.24	0.10	1.08	2.75	32	42	26	LOAM
46	"	12	7095	100	6.07	0.22	0.12	1.26	2.64	26	46	28	CLAY LOAM
47	"	12	7096	200	6.08	0.21	0.11	1.26	2.53	28	44	28	CLAY LOAM
48	Lok Bahadur	13	7097	0-20	6.33	0.59	0.14	1.68	8.48	22	46	32	CLAY LOAM
49	Dhading, Gauthal	13	7098	20-40	6.43	0.55	0.10	1.08	4.07	20	48	32	CLAY LOAM/SILTY CLAY LOAM
50	"	13	7099	40-100	6.43	0.51	0.10	1.28	3.74	16	50	34	SILTY CLAY LOAM
51	"	13	8000	100-200	6.49	1.03	0.09	0.96	2.97	20	40	40	CLAY/CLAY LOAM/SILT CLAY / SILT CLAY LOAM
52	Lal Bahadur	14	8001	0-20	5.54	0.16	0.09	1.15	3.52	40	46	14	LOAM
53	Dhading, Gauthal	14	8002	20-40	5.66	0.16	0.08	1.11	3.52	38	48	14	LOAM
54	"	14	8003	40-100	5.56	0.17	0.08	0.92	2.97	40	44	16	LOAM
55	"	14	8004	100-200	5.67	0.08	0.05	0.75	2.75	44	42	14	LOAM
56	Chaabi Bahadur	15	8005	0-20	6.14	0.16	0.17	1.18	4.29	24	50	26	SILT LOAM/LOAM
57	Dhading, Gauthal	15	8006	20-40	5.98	0.1	0.14	0.79	3.08	22	50	28	CLAY LOAM
58	"	15	8007	40-100	5.6	0.15	0.13	0.7	2.64	20	46	34	CLAY LOAM/SILTY CLAY LOAM
59	"	15	8008	100-200	5.2	0.22	0.13	0.57	1.98	16	44	40	SILTY CLAY/SILTY CLAY LOAM
60	Toy Bahadur	16	8009	0-20	5.99	0.2	0.10	1.27	17.5	26	46	28	CLAY LOAM
61	Dhading, Gauthal	16	8010	20-40	6.02	0.17	0.11	1.3	13.65	24	48	28	CLAY LOAM
62	"	16	8011	40-100	6.05	0.19	0.10	1.3	14.2	24	48	28	CLAY LOAM
63	"	16	8012	100-200	5.86	0.28	0.10	1.34	18.69	40	28	32	CLAY LOAM

64	Khum Bahadur	17	8013	0-20	5.72	0.17	0.11	0.94	11.05	18	48	34	SILTY CLAY LOAM
65	Dhading, Gauthal	17	8014	20-40	5.85	0.19	0.11	1.02	12.81	16	50	34	SILTY CLAY LOAM
66	"	17	8015	40-100	5.75	0.16	0.11	0.98	11.87	12	52	36	SILTY CLAY LOAM
67	"	17	8016	100-200	5.89	0.17	0.13	0.9	12.81	12	52	36	SILTY CLAY LOAM
68	Kul Bahadur	18	8017	0-20	5.98	0.14	0.13	1.3	57.11	24	52	24	SILT LOAM
69	Dhading, Gauthal	18	8018	20-40	5.84	0.13	0.12	1.27	49.48	26	48	26	LOAM
70	"	18	8019	40-100	5.89	0.16	0.13	1.17	45.48	24	50	26	SILT LOAM/LOAM
71	"	18	8020	100-200	5.93	0.18	0.12	1.12	71.92	22	50	28	CLAY LOAM
72	Krishna Bahadur	19	8021	0-20	5.97	0.23	0.12	1.02	9.87	32	46	22	LOAM
73	Dhading, Gauthal	19	8022	20-40	5.94	0.19	0.12	0.98	8.23	36	44	20	LOAM
74	"	19	8023	40-100	5.94	0.21	0.10	0.82	7.4	36	44	20	LOAM
75	"	19	8024	100-200	5.94	0.27	0.11	0.97	12.93	38	42	20	LOAM
76	Yeak Bahadur	20	8025	0-20	5.92	0.11	0.12	0.71	1.65	24	51	25	SILT LOAM
77	Dhading, Gauthal	20	8026	20-40	5.96	0.09	0.10	0.34	2.12	26	50	24	SILT LOAM/LOAM
78	"	20	8027	40-100	5.94	0.08	0.10	0.5	0.94	26	48	26	LOAM
79	"	20	8028	100-200	5.92	0.12	0.11	0.51	0.82	24	48	28	CLAY LOAM

Table: Analytical results of the soils collected from Tawari village

Field No	Location	Pit No.	Lab No.	Soil depth	pH	K (me)	Total N (%)	Org C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	TEXTURE
80	Kabita Tamang	21	8029	0-20	5.67	0.40	0.16	1.96	15.51	32	48	20	LOAM
81	Kabhre, Tawari	21	8030	20-40	5.37	0.11	0.13	1.32	6.93	32	50	18	SILT LOAM/LOAM
82	"	21	8031	40-100	5.37	0.08	0.12	1.19	8.58	30	52	18	SILT LOAM
83	"	21	8032	100-200	5.33	0.10	0.12	1.3	15.28	26	54	20	SILT LOAM
84	Samjhana Tamang	22	8033	0-20	5.56	0.39	0.14	1.57	5.88	28	52	20	SILT LOAM
85	Kabhre, Tawari	22	8034	20-40	5.57	0.21	0.13	1.23	10.22	34	47	19	LOAM
86	"	22	8035	40-100	5.75	0.16	0.09	0.95	11.05	28	53	19	SILT LOAM
87	Man Bd. Tamang	23	8036	0-20	5.52	0.27	0.15	1.58	9.87	36	51	13	SILT LOAM
88	Kabhre, Tawari	23	8037	20-40	5.3	0.00	0.12	1.09	4.82	32	54	14	SILT LOAM
89	"	23	8038	40-100	5.48	0.09	0.08	0.74	4.47	30	58	12	SILT LOAM
90	"	23	8039	100-200	5.54	0.08	0.07	0.79	2.12	28	54	18	SILT LOAM
91	Chameli Tamang	24	8040	0-20	5.32	0.59	0.13	1.44	7.76	38	50	12	SILT LOAM/LOAM
92	Kabhre, Tawari	24	8041	20-40	5.43	0.19	0.06	0.51	1.76	36	52	12	SILT LOAM
93	"	24	8042	40-100	5.53	0.19	0.02	0.1	0.71	38	50	12	SILT LOAM/LOAM
94	"	24	8043	100-200	5.48	0.18	0.01	0	0.71	44	46	10	LOAM
95	Rupa Devi Bhujl	25	8044	0-20	5.53	0.36	0.16	1.7	4.94	14	62	24	SILT LOAM
96	Kabhre, Tawari	25	8045	20-40	5.48	0.18	0.16	1.13	4.26	18	58	24	SILT LOAM
97	"	25	8046	40-100	5.46	0.21	0.18	1.47	4.6	16	54	30	SILTY CLAY LOAM
98	"	25	8047	100-200	5.54	0.12	0.14	1.68	2.42	16	62	22	SILT LOAM
99	Urmila Thapa	26	8048	0-20	5.73	0.38	0.17	2	8.51	20	59	21	SILT LOAM
100	Kabhre, Tawari	26	8049	20-40	5.81	0.18	0.11	1.22	5.06	20	59	21	SILT LOAM
101	"	26	8050	40-100	5.77	0.12	0.09	0.98	2.88	18	57	25	SILT LOAM
102	"	26	8051	100-200	5.53	0.10	0.05	0.43	0.35	16	54	30	SILTY CLAY LOAM

103	Laxmi Magar	27	8052	0-20	5.72	0.26	0.19	2.26	13.12	18	66	16	SILT LOAM
104	Kabhre, Tawari	27	8053	20-40	5.65	0.18	0.14	1.78	9.66	16	66	18	SILT LOAM
105	"	27	8054	40-100	5.75	0.11	0.10	1.06	5.29	16	66	18	SILT LOAM
106	Rumila Magar	28	8055	0-20	5.64	0.15	0.13	1.51	4.6	16	64	20	SILT LOAM
107	Kabhre, Tawari	28	8056	20-40	5.6	0.09	0.10	1.1	4.14	16	62	22	SILT LOAM
108	"	28	8057	40-80	5.57	0.09	0.09	1.01	4.14	16	60	24	SILT LOAM
109	Sunita Tamang	29	8058	0-20	5.45	0.20	0.16	2.31	8.28	24	60	16	SILT LOAM
110	Kabhre, Tawari	29	8059	20-40	5.41	0.13	0.15	1.86	1.27	22	58	20	SILT LOAM
111	"	29	8060	40-100	5.33	0.08	0.08	1.07	0.92	22	56	22	SILT LOAM
112	"	29	8061	100-200	5.5	0.07	0.05	0.59	0.69	26	54	20	SILT LOAM
113	Ranjana Magar	30	8062	0-20	5.29	0.27	0.17	2.03	21.63	26	58	16	SILT LOAM
114	Kabhre, Tawari	30	8063	20-40	5.38	0.14	0.12	1.24	9.32	24	60	16	SILT LOAM
115	"	30	8064	40-100	5.32	0.12	0.08	0.88	9.2	26	52	22	SILT LOAM
116	"	30	8065	100-200	5.26	0.16	0.08	0.8	5.41	24	54	22	SILT LOAM
117	Rumila Magar	28	8066	80-100	5.53	0.10	0.05	0.45	0.35	18	50	32	SILTY CLAY LOAM

Table: Analytical results of the soils collected from Ange village

Field No	Location	Pit No.	Lab No.	Soil depth	pH	K (me)	Total N (%)	Org C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	TEXTURE
118	Rani Tamang	31	8067	0-20	5.43	0.2	0.08	1	22.56	64	22	14	SANDY LOAM
119	Sindhu, Ange	31	8068	20-40	5.35	0.15	0.07	0.84	17.75	60	26	14	SANDY LOAM
120	"	31	8069	40-100	5.42	0.18	0.06	0.85	35.96	62	24	14	SANDY LOAM
121	"	31	8070	100-200	5.48	0.21	0.04	0.46	5.76	58	24	18	SANDY LOAM
122	Lok k. Khadka	32	8071	0-20	5.12	0.17	0.07	0.79	30.91	66	22	12	SANDY LOAM
123	Sindhu, Ange	32	8072	20-40	5.29	0.11	0.05	0.49	8.42	64	22	14	SANDY LOAM
124	"	32	8073	40-100	5.44	0.11	0.03	0.37	18.36	62	24	14	SANDY LOAM
125	"	32	8074	100-200	5.43	0.14	0.04	0.37	5.15	50	28	22	SANDY CLAY LOAM/LOAM
126	Man K. Khadka	33	8075	0-20	5.46	1.06	0.13	1.48	149.72	68	23	9	SANDY LOAM
127	Sindhu, Ange	33	8076	20-40	5.51	0.80	0.09	0.93	155.57	70	22	8	SANDY LOAM
128	"	33	8077	40-100	5.72	1.08	0.07	0.95	167.26	68	23	9	SANDY LOAM
129	"	33	8078	100-200	5.8	1.15	0.06	0.84	185.98	64	24	12	SANDY LOAM
130	Ram M. Tamang	34	8079	0-20	5.42	0.25	0.07	0.78	26.2	68	24	8	SANDY LOAM
131	Sindhu, Ange	34	8080	20-40	5.32	0.19	0.31	0.73	9.47	64	26	10	SANDY LOAM
132	"	34	8081	40-100	5.38	0.19	0.05	0.58	9.83	58	26	16	SANDY LOAM
133	"	34	8082	100-200	5.55	0.17	0.03	0.4	6.78	54	28	18	SANDY LOAM
134	Dev K. Khadka	35	8083	0-20	5.11	0.17	0.08	0.88	6.78	66	22	12	SANDY LOAM
135	Sindhu, Ange	35	8084	20-40	5.26	0.10	0.07	0.68	3.63	66	24	10	SANDY LOAM
136	"	35	8085	40-100	5.3	0.11	0.06	0.67	1.52	78	6	16	SANDY LOAM
137	"	35	8086	100-200	5.26	0.11	0.04	0.6	1.29	58	26	16	SANDY LOAM
138	Sukurani Tamang	36	8087	0-20	5.07	0.13	0.09	0.85	29.24	64	22	14	SANDY LOAM
139	Sindhu, Ange	36	8088	20-40	5.05	0.21	0.06	0.64	20.12	66	22	12	SANDY LOAM
140	"	36	8089	40-100	5.28	0.12	0.05	0.55	20.12	66	20	14	SANDY LOAM
141	"	36	8090	100-200	5.5	0.12	0.03	0.29	8.07	64	30	6	SANDY LOAM

142	Fulthunga Khadka	37	8091	0-20	5.42	0.35	0.03	0.34	183.64	76	20	4	SANDY LOAM/LOAMY SAND
143	Sindhu, Ange	37	8092	20-40	5.45	0.38	0.04	0.37	166.09	76	20	4	SANDY LOAM/LOAMY SAND
144	"	37	8093	40-100	5.32	0.38	0.04	0.43	138.02	76	20	4	SANDY LOAM/LOAMY SAND
145	"	37	8094	100-200	5.54	0.42	0.04	0.46	147.38	78	17	5	LOAMY SAND
146	Sabitri Khadka	38	8095	0-20	5.53	0.14	0.03	0.24	45.15	76	19	5	LOAMY SAND
147	Sindhu, Ange	38	8096	20-40	5.52	0.11	0.01	0.15	35.79	74	20	6	SANDY LOAM
148	"	38	8097	40-100	5.62	0.07	0.01	0.13	14.15	73	20	7	SANDY LOAM
149	Santa Kumari	39	8098	0-20	5.26	0.16	0.08	1.02	47.72	73	19	8	SANDY LOAM
150	Sindhu, Ange	39	8099	20-40	5.25	0.09	0.08	0.88	36.14	74	18	8	SANDY LOAM
151	"	39	8100	40-100	5.43	0.10	0.06	0.83	34.62	72	20	8	SANDY LOAM
152	"	39	8101	100-200	5.32	0.07	0.05	0.71	41.29	73	17	10	SANDY LOAM
153	Bhim K. Khadka	40	8102	0-20	4.87	0.20	0.10	1.34	23.28	60	26	14	SANDY LOAM
154	Sindhu, Ange	40	8103	20-40	5.13	0.14	0.08	0.99	14.15	56	26	18	SANDY LOAM
155	"	40	8104	40-100	5.24	0.15	0.06	0.99	30.76	58	22	20	SANDY LOAM/SANDY CLAY LOAM
156	"	40	8105	100-200	5.45	0.27	0.05	0.87	56.25	50	26	24	SANDY CLAY LOAM

Table: Analytical results of the soils collected from Chankhubensi village

Field No	Location	Pit No.	Lab No.	Soil depth	pH	K (me)	Total N (%)	Org C (%)	P-Bray (ppm)	Sand (%)	Silt (%)	Clay (%)	TEXTURE
157	Susmitra Parajul	41	8106	0-20	4.6	0.28	0.10	1.27	244.02	38	46	16	LOAM
158	Chankhubensi	41	8107	20-40	4.64	0.20	0.09	1.02	215.38	40	44	16	LOAM
159	"	41	8108	40-100	4.92	0.12	0.07	0.79	63.93	40	44	16	LOAM
160	"	41	8109	100-200	5.18	0.15	0.06	0.7	22.45	36	44	20	LOAM
161	Sarada Parajuli	42	8110	0-20	5.02	0.24	0.12	1.52	28.3	40	42	18	LOAM
162	Chankhubensi	42	8111	20-40	5.19	0.08	0.10	1	12.26	36	46	18	LOAM
163	"	42	8112	40-100	5.23	0.08	0.06	0.58	6.3	40	40	20	LOAM
164	"	42	8113	100-200	5.34	0.14	0.04	0.38	9.62	38	42	20	LOAM
165	Menka Aryal	43	8114	0-20	5.15	0.49	0.13	1.6	134.04	40	46	14	LOAM
166	Chankhubensi	43	8115	20-40	5.08	0.24	0.08	0.92	93.94	12	52	36	SILTY CLAY LOAM
167	"	43	8116	40-100	5.09	0.27	0.05	0.54	53.73	38	44	18	LOAM
168	Subhadra Koirla	44	8117	0-20	5.2	0.16	0.08	1.01	20.51	54	34	12	SANDY LOAM
169	Chankhubensi	44	8118	20-40	5	0.08	0.05	0.47	6.19	54	33	13	SANDY LOAM
170	"	44	8119	40-100	5.22	0.08	0.04	0.41	4.12	42	46	12	LOAM
171	"	44	8120	100-200	5.48	0.13	0.02	0.17	2.63	70	20	10	SANDY LOAM
172	Parvati Ghimire	45	8121	0-20	4.81	0.16	0.12	1.41	56.02	44	36	20	LOAM
173	Chankhubensi	45	8122	20-40	4.81	0.08	0.09	1.17	67.94	44	37	19	LOAM
174	"	45	8123	40-100	5.11	0.07	0.09	1.11	42.16	46	35	19	LOAM
175	"	45	8124	100-200	5.1	0.09	0.08	1.07	25.43	44	36	20	LOAM
176	Kainhali Tamang	46	8125	0-20	5.37	0.12	0.10	1.15	36.89	40	43	17	LOAM
177	Naya Gawn	46	8126	20-40	5.43	0.07	0.08	1	25.32	36	46	18	LOAM
178	"	46	8127	40-100	5.43	0.06	0.07	0.73	17.53	40	43	17	LOAM
179	"	46	8128	100-200	5.54	0.06	0.08	0.63	10.08	40	42	18	LOAM
180	Chitra Kumari	47	8129	0-20	5.47	0.38	0.14	1.7	143.43	40	45	15	LOAM

181	Naya Gawn	47	8130	20-40	5.52	0.22	0.09	1.1	45.37	38	44	18	LOAM
182	"	47	8131	40-100	5.51	0.17	0.11	1.56	27.04	38	44	18	LOAM
183	"	47	8132	100-200	5.25	0.11	0.04	0.48	3.44	38	42	20	LOAM
184	Chandra Kumari	48	8133	0-20	5.76	1.31	0.09	1.01	139.77	46	42	12	LOAM
185	Naya Gawn	48	8134	20-40	5.73	1.35	0.10	1.07	197.05	40	46	14	LOAM
186	"	48	8135	40-100	5.34	0.92	0.07	0.78	127.17	38	44	18	LOAM
187	"	48	8136	100-200	5.4	1.03	0.09	1.1	276.1	38	44	18	LOAM
188	Manmaya Magar	49	8137	0-20	5.12	0.10	0.08	0.92	33.57	42	42	16	LOAM
189	Naya Gawn	49	8138	20-40	5.35	0.07	0.08	0.56	8.94	44	40	16	LOAM
190	"	49	8139	40-100	5.36	0.07	0.05	0.55	4.12	40	41	19	LOAM
191	"	49	8140	100-200	0	0.05	0.02	0.51	1.37	42	39	19	LOAM

Appendix 3: Amount of fertilizer and compost applied by the farmers in five villages

Name of Farmer	Village	Chemical Fertilizer used (Kg/ropani)				Organic Fertilizer (Doko / ropani)	
		Urea	AS/P	TSP/DAP	Frequency	Compost	Frequency
Top Bdr.	Gajurichhap	4	-	-	3	20	1
Eak Bdr.	"	4	-	-	2	25	1
Sumitra Magar	"	0	-	-	0	12	1
Amar Bdr.	"	5	-	-	1	25	1
Ganesh Bdr.	"	3	-	-	1	20	1
Dhana Bdr.	"	4	-	-	1	25	1
Lila Bdr.	"	3	1	3	1	5	1
Budhi Bdr.	"	6		2	1	25	1
Hari Bdr.	"	0	-	-	-	24	1
Man Bdr.	"	4	-	3	1	22	1
Dhana Bdr.	Gauthale	0	-	-	-	7	1
Bhim Bdr. Ale	"	0	-	-	-	30	1
Lok Bdr.	"	4	-	-	1	30	1
Lal Bdr. Magar	"	5	-	-	1	30	1
Chaabi Bdr.	"	0	-	-	-	24	1
Toy Bdr.	"	0	-	-	-	24	1
Khum Bdr. Magar	"	1	-	-	1	24	1
Kul Bdr. Magar	"	2	-	-	1	10	1
Krishna Bdr.	"	3	0.5	1	1	30	1
Yeak Bdr. Magar	"	4	-	-	1	20	1
Kabita Tamang	Tawari	6	-	-	1	40	1
Samjhana Tamang	"	17	-	-	1	25	1
Man Bdr.	"	25	-	-	1	25	1
Chameli	"	15	-	-	1	25	1
Rupa Devi	"	8	-	-	1	35	1
Urmila Tamang	"	30	-	-	1	30	1
Laxmi Magar	"	17			1	30	1
Rumila Magar		16	-	-	1	35	1
Sumitra Magar	"	9			1	25	1
Ranjana Magar	"	15	-	-	1	25	1
Rani Tamang	Ange	10	-	-	2	30	1
Lok K. Khadka		8	-	-	1	25	1
Man K. Khadka	"	8	-	-	1	35	1
Ram Maya	"	4	-	-	1	30	1
Santa K.	"	14	-	-	1	17	1
Sukurani	"	5	-	-	1	25	1
Phulthunga	"	0			1	0	1
Sabitri Khadka	"	10			1	25	1
Santa K. Khadka	"	6	-	-	1	17	1
Bhim K.	"	7	-	-	1	20	1
Susmitra Parajuli	Chankhube	20	-	-	1	40	1
Sarada Parajuli	"	10	-	-	1	20	1
Menka Aryal	"	11	-	-	1	20	1
Subhadra Koirala	"	12			1	25	1
Parbati Ghimire	"	10			1	30	1
Kainlhi Tamang	"	13	-	-	1	35	1
Chitra Kumari	"	20			1	30	1
Chandra K. Khadka	"	25	-	-	1	35	1
Manmaya Magar	"	14	-	-	1	25	1

Appendix 4: Fertility rating for forest soils

Analysis	Method used	Rating range				
		Very High	High	Medium	Low	V. low
pH	1:2.5 soil:water suspension	V. alkaline > 8.0	Alkaline 7.5 – 8.0	Neutral 6.0 - 7.5	Acidic 4.5-6.0	v. acidic 3.5-4.5
K (me/100g)	1 M NH4OAc soln at pH 7.0	>0.8	0.4-0.8	0.2-0.4	0.1-0.2	0.0-0.1
P (ppm)	Bray (dilute HCl / H2SO4)	>30	22-30	14-22	7-14	4-7
Organic Matter (%)	Walkley - Black	>5.0	3.0-5.0	1.5-3.0	0.4-1.5	0.2-0.4
Total Nitrogen (%)	Micro Kjeldahl	>0.2	0.15-0.20	0.08-0.15	0.08-0.04	0.02-0.04

Source: DFRS

Fertility rating for agricultural soils

Analysis	Method used	Rating range				
		Very High	High	Medium	Low	V. low
pH	1:2.5 soil:water suspension	V. alkaline > 8.3	Alkaline 7.0 - 8.3	Neutral 6.6 - 7.0	Acidic 5.9 - 6.6	v. acidic < 5.9
K2O (kg/ha)	1 M NH4OAc soln at pH 7.0	>500	280 - 500	110 - 280	55 - 110	< 55
P2O5 (kg/ha)	Bray (dilute HCl / H2SO4)	>110	55 - 110	30 - 55	10 - 30	<10
Organic Matter (%)	Walkley - Black	>10	5.0 - 10.0	2.5 - 5.0	1.0 - 2.5	<1.0
Total Nitrogen (%)	Micro Kjeldahl	> 0.4	0.2 - 0.4	0.1 - 0.2	0.05 - 0.1	< 0.05

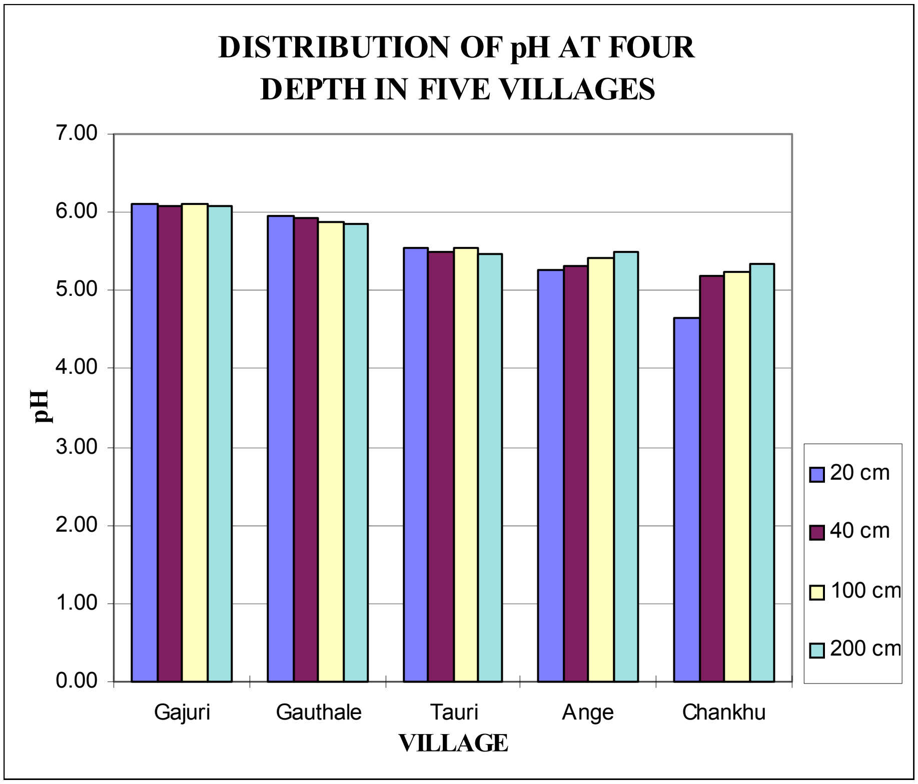
Source: NARC, 1999.

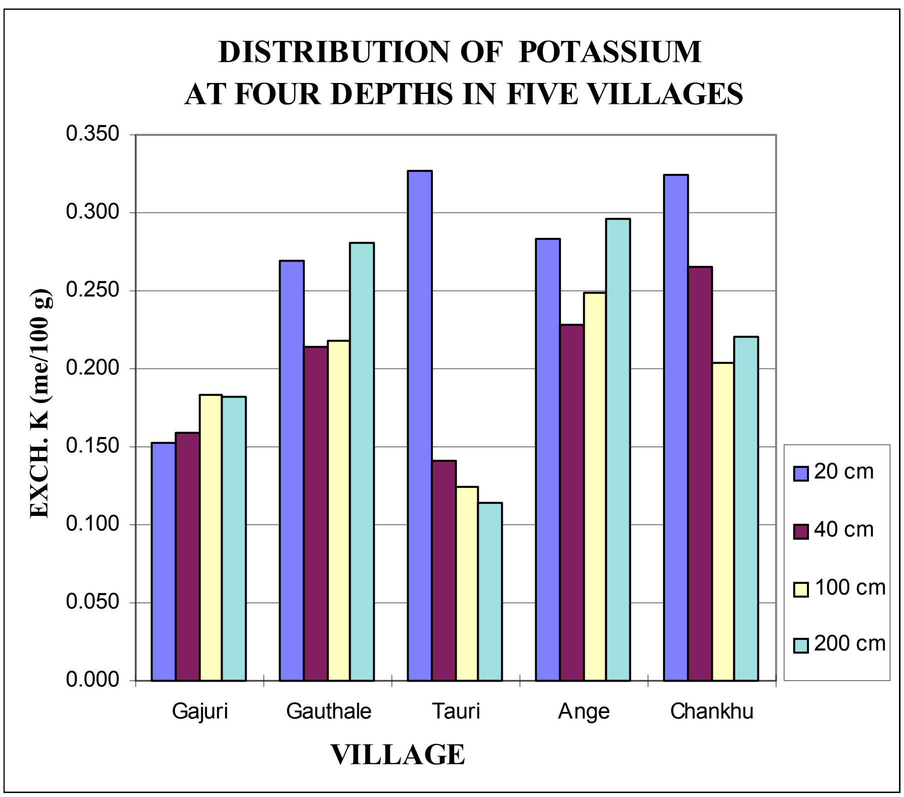
Appendix 5: Site requirements of three fodder species

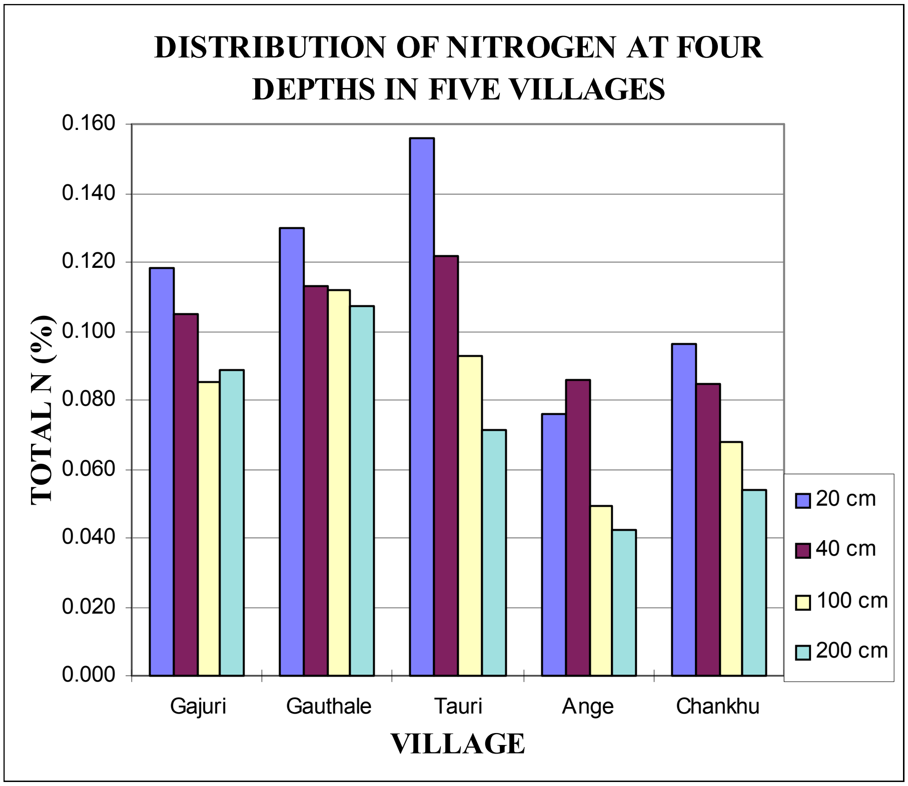
Species	Site requirements						
	Altitude (m)	Rainfall (mm)	Light	Frost	Drainage	moisture	Soil fertility
A. lakoocha	Terai-1300	_	Full light	Intoleran t	good	Adequate	deep fertile
L. diversifolia	30-1500	1200-3500		Intoleran t	good	_	_
M. alba	12-2400		Overhead light		well		Deep, fertile loamy

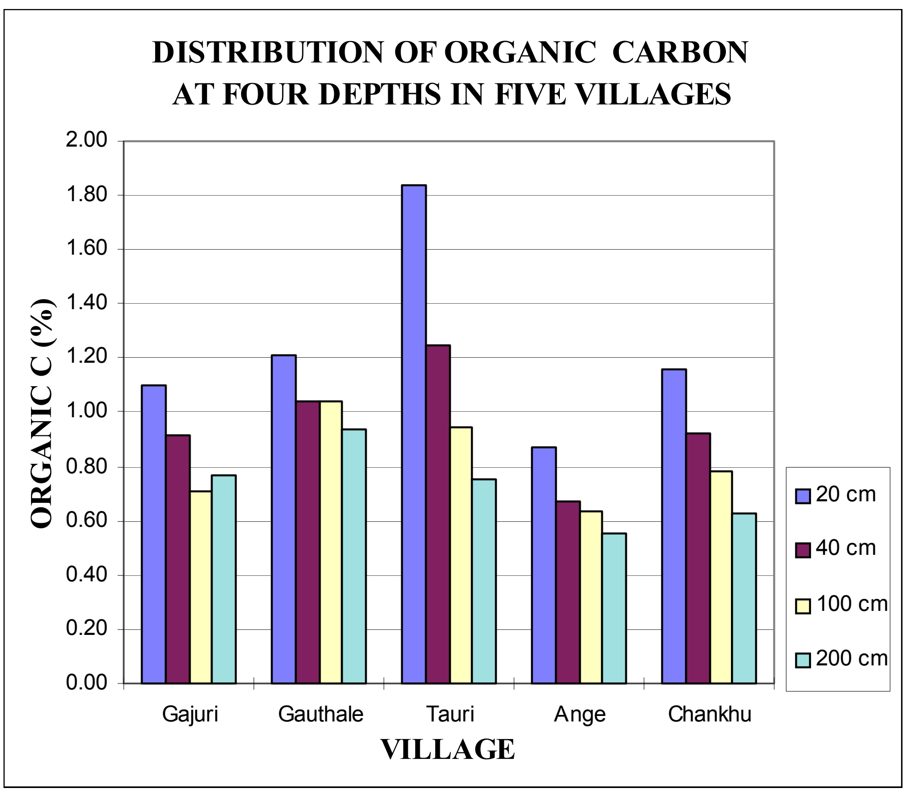
Source: Howell, 1986 and Jackson, 1994

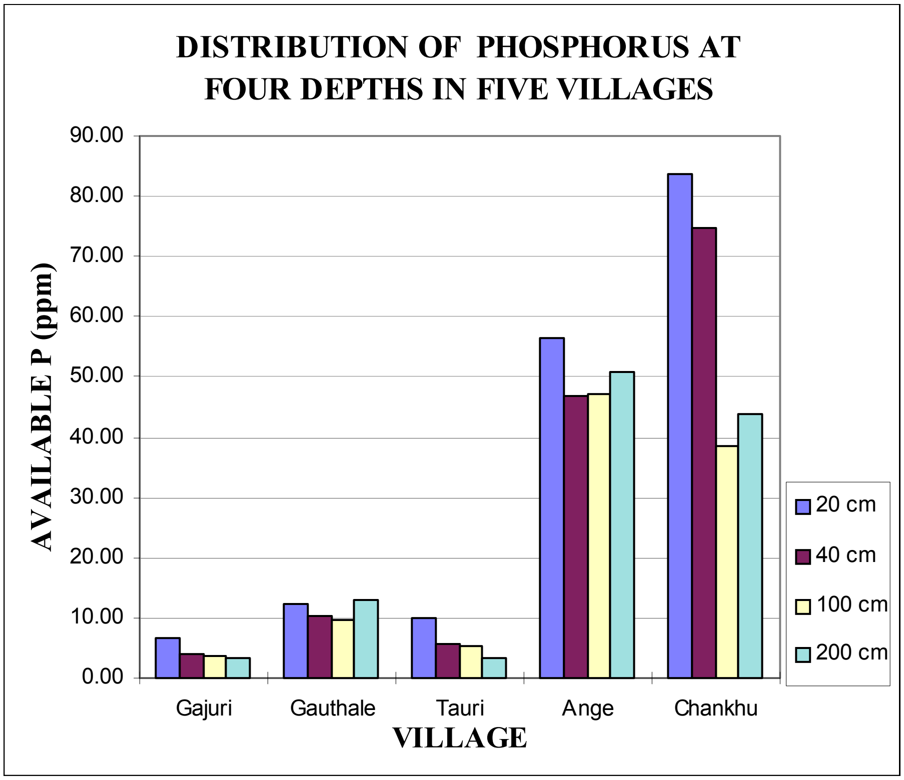
Appendix 6: Chart showing distribution of pH, C, N, P, K, Sand, Silt and Clay at four depths in five villages.

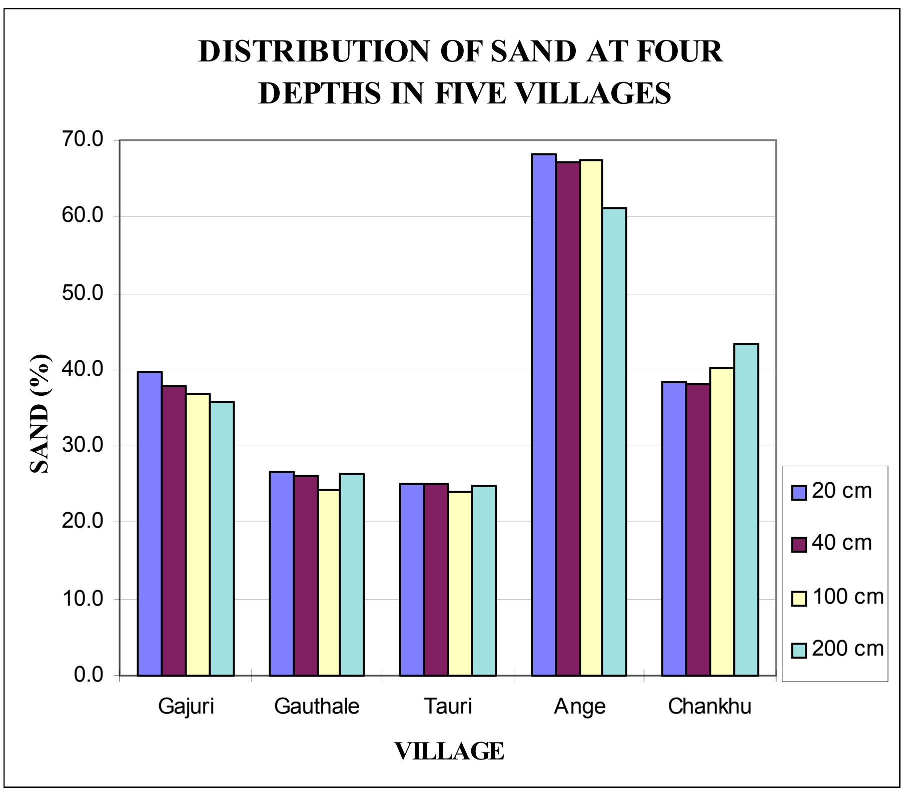


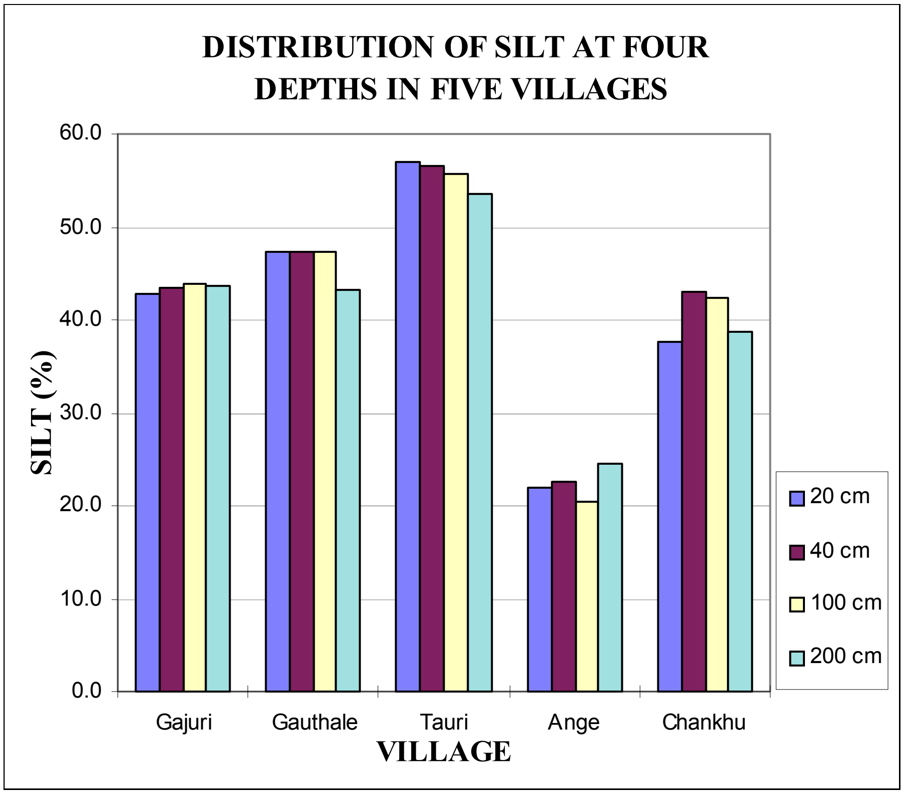


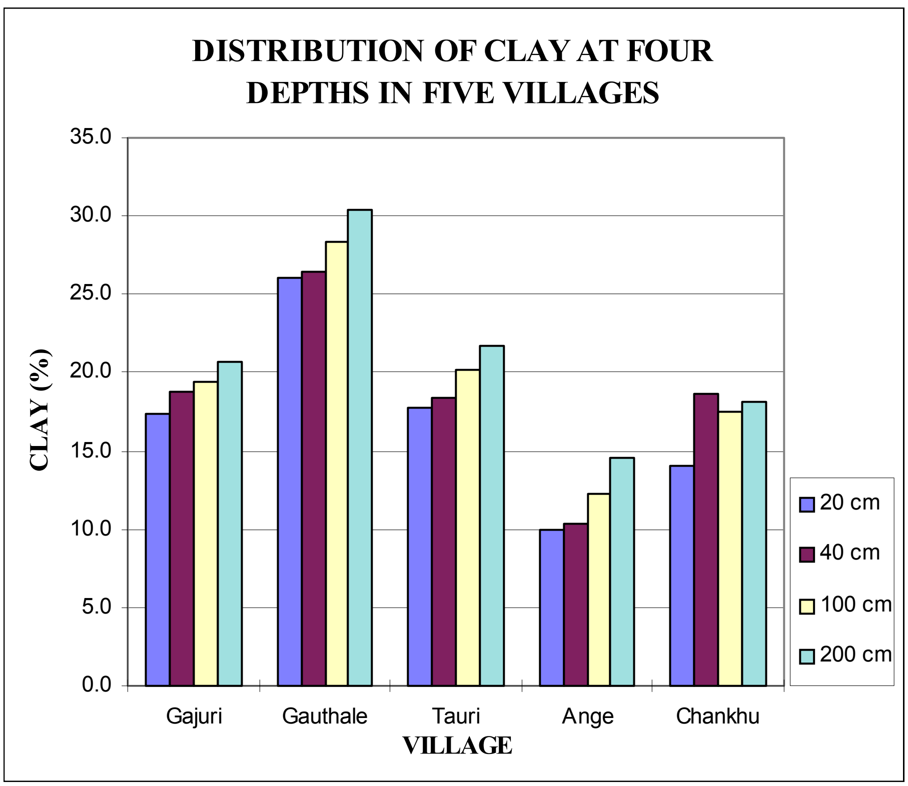

DISTRIBUTION OF NITROGEN AT FOUR DEPTHS IN FIVE VILLAGES
TOTAL N (%)
0.000
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.160
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm


DISTRIBUTION OF ORGANIC CARBON AT FOUR DEPTHS IN FIVE VILLAGES
ORGANIC C (%)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm


DISTRIBUTION OF PHOSPHORUS AT FOUR DEPTHS IN FIVE VILLAGES
AVAILABLE P (ppm)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm


DISTRIBUTION OF SAND AT FOUR DEPTHS IN FIVE VILLAGES
SAND (%)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm


DISTRIBUTION OF SILT AT FOUR DEPTHS IN FIVE VILLAGES
SILT (%)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm


DISTRIBUTION OF CLAY AT FOUR DEPTHS IN FIVE VILLAGES
CLAY (%)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Gajuri
Gauthale
Tauri
Ange
Chankhu
VILLAGE
20 cm
40 cm
100 cm
200 cm