

# **1. INTRODUCTION**

## **1.1 Background**

Nepal occupies a unique position due to its geographical position and due to the variation in altitude and environment. This small country with its amazing range of variation governed by both horizontal and vertical factors is recognized as the “National show room of biodiversity”.

Variation brings diversity and a wide range of environmental or genetical factors brings variation. With the variation in temperature vertically and with the variation in rainfall horizontally, it ensures to bring variation within and among plant population.

Natural population of a Plant shows intricate pattern of variation (Briggs and Walter, 1997). Variability and diversity of morphological character of plant is precisely influenced by its gene and the environment to which it exposes (Joshi et al 1998). Phenotypic traits of plant between different populations are expected due to their possible genetic variability, environment and interaction between them. (Shelton, 1978).

Differences in form or function between individual or populations or species are regarded as variation. Variations arise due to environmental modification, genetic recombination, mutation & selection. Variation is a major aspect to compare population and to select the superior traits for breeding purpose (Gupta&Sehgal, 2000).The variation may arise within population, between

population and among population. Variation within & between the population gives us idea about economic or commercially important trait while variation among the population gives us the close picture of the survival & adaptability of the population.

Geographical variation is often the most important characteristics relates to Survival and adaptability. Geographical variation is the phenotypic differences among native plants that are growing in different portion of species range. If the differences are largely genetic rather than environmental, the variation is usually specific. Variation is Phenotypically Significant for the selection of superior plants.

Phenotypic variation occurs due to environmental action and can be observed by calculating morphological differences. However, variability and diversity in phenotypic character of the plant are greatly influenced by its genotype and environment to which it is exposed. It results due to combined effect of gene or environment or the both.

This research has been carried out to study the phenotypic variation between and within population of *solanum nigrum L* due to climatic and edaphic factors. The phenotypic characters of plants between different populations are expected owing to their possible genetic variability, environment and interaction between them. However due to limited period of time and inadequate laboratory facilities research on molecular level couldn't possible to check out genetic variation.



*Solanum nigrum L*

**Fig No.1 Illustrated Diagram of *Solanum nigrum* Linn.**

## 1.2 Distribution and Taxonomic Description

Division	–	Magnaliophyta
Class	–	Magnaliopsida
Sub-class	–	Asteridae
Order	–	Solanales
Family	–	Solanaceae
Genus	–	Solanum
Species	–	Nigrum (Cronquist, 1988)

Scientific name: *Solanum nigrum* Linn

(Bentham and Hooker, 1883, Hara et al 1978)

Synonyms: *Solanum purpureilineatum*

(Singh et al 1983, Press et al 2000).

### 1.2.1 DISTRIBUTION

*Solanum nigrum* Linn (Nepali – Jungali kalo bihi, Sanskrit kakamachi, English – black night shade) is a cosmopolitan tropical, sub-tropical and temperate seed belongs to family solanaceae distributed through out the world. In Nepal the plant is found 180m to 2900m through out eastern, central and western Nepal. In Nepal 17 species of solanum are found (Press et al 2000) *S. nigrum* linn with diploid Chromosome number 24 and 46. (Darlington, 1955). It

generally prefers to grow in open places near road sides. (Malla et al 1984).

## **1.2.2 TAXONOMIC DESCRIPTION**

*Solanum nigrum Linn* is an erect, prostrate, glabrous, sparsely pubescent herb. It attains a height of 1.4 cm, stem branched, Leaves alternate or in equal pair, petiolate, ovate or lanceolate, base narrow, margin enter sinuate, toothed, lobed, acute, acuminate, membranous, glabrous. Inflorescne a subumbelled raceme. Flower 1 cm in diameter, spreading, white, calyx 5, ovate, obtuse. Corollas 5 lobed stamens 5, filament short, anther oblong, style slender, fruit purple black berry.

## **1.3 Economic Importance**

### **1.3.1 Medicinal Use**

*Solanum nigrum Linn* is a plant with versatile medicinal prosperities. The herb has antiseptic and anti dysenteric properties and in given internally for cardalgin and gripe. An infusion of the plant is sued as an enema in intents having abdominal upsets. It is a household remedy for anthrax and is applied locally (V.S. Agrawal 1986). It has also used for its diuretic and laxative properties and its decotion is regarded as an antispasmodic and narcotic. Freshly prepared extract of plant is effective in the treatment of cirrhosis of the liver, and also serues as an antidose to optimum poisoning .An alcoholic extract of leaves is active against *Staphylococcus aurea* and *Escherichia coli*. (Chopra, 1956)

Berries are considered to possess tonic, diuretic properties and are useful in amnesia and heart disease. They are a domestic remedy for fevers, diarrhea, ulcers and eye troubles.

### **1.3.2 Edible Uses**

Leaves and tender shoots of *S.nigrum* are taken in the same way as spinach and eaten in many parts of India, especially by patients suffering from dryops. Ripe fruits are used in piles and pressure; they are sometimes used as a substitute for raisins in plum puddings. Fruits make a delightful Jam.

### **1.3.3 Toxic Effect**

Green Unripe fruits contain glycol alkaloids and their eating is toxic hazard to human beings as well as live stock – Ripe Fruit contains very little alkaloids and can be consumed without ill effects. (The Wealth of India).

## **1.4 Chemical Composition**

Analysis of leaves gave the following values (in 100 gm edible material): moisture, 82.1, protein, 5.9; fat, 1.0; minerals, 2.1; and carbohydrates, 8.9 g. ca, 410; p, 70; and Fe, 20.5 gm 100 gm. Leaf is a rich source of riboflavin, 0.59; nicotinic acid, 0.92 and vitamin c, 100.g mg. Fruit contain glucose and fructose (15-20%), vitamin c and b-carotene. Seeds, forming 9.5 percent of the weight of the fresh fruit contain 17.5 percent on dry weight basis. They yield greenish yellow oil (21.5%).

Green fruit of the plant contains four steroids glycoallacloisd, viz. solamargine, Solasonine and  $\alpha$ - and  $\beta$  - solanigrane; all of them yield. solasodine as the aglycone. It also contains a steroidal genin, tigogenin (m.p-1, 206-07<sup>0</sup>). Solamargine and solasonine are also resented in leaves. The total alkaloid content of fruits and leaves are respectively 0.101 and 0.431 percent. (The wealth of India).

## **1.5 Justification**

*Solanum nigrum* L. is the important medicinal plant of human use as it contains large number of valuable medicinal compounds of multiple use but the proper attention is not given for the conservation, management, improvement and utilization. In this context, phenotypic variation becomes one of the major aspects for variation studies. Natural population of plants shows intricate patterns of variation (Briggs and Walters, 1997) and variation is important to select superior stands for breeding purpose (Gupta and Sehgal, 2000). Study of variation in phenotypic traits also help to select productivity and adopt shifting ecological conditions. Thus, this study help to recognize phenotypically superior plant population for domestication, management and conservation of *Solanum nigrum* L.

## **1.6 Objectives**

The main objectives of the present work are as follows:

1. To access the phenotypic variation in *Solanum nigrum* L. within and among population under natural habitats.
2. To determine the correlation between morphological characters.
3. To recognize the phenotypically superior stand with adaptive characters for domestication.
4. To recognize the effect of environmental variation towards pollen viability.

## **1.7 Limitations**

A limited time period did not allow undertaking progeny test and reciprocal transplant experiment which is considered to be the confirmatory test for the pattern of variation studies. The number of plant individuals might be the limitation of this study. In this present study plants from the eastern region could not taken.

## **2. Literature Review**

### **2.1 Study Inside and Outside Nepal**

Witcombe and Rao (1976) studied the genecology of wheat in a Nepalese center of diversity. They reported that distribution of morphological variability of wheat in eastern Nepal. Variations in characters were also correlated with altitude of origin.

Morrison and Western (1985) studied the morphological variation in a field sample of *Caladenia catenata* Druce. A morphological analysis of the variation among 24 attributes of a field sample of 71 plants of the *Caladenia catenata* Druce species complex from sydney region suggests that there are two phonetically distinct polythetic taxa within the orchid group.

Ross and Hawkins (1986) studied genetic variation among local population of Jack pine (*Pinus banksiana*). They concluded that knowledge of the application of genetic variation within and among plant population are important for understanding the evolution of reproductive strategies of adaptations to local conditions.

Joshi and Joshi (1988) studied genetic diversity of *Alnus nepalensis*. They estimated 11 stands at different latitude, longitudes and altitudes with 58 trees in the forest of eastern, central and western Nepal for provenance variation in *Alnus nepalensis*. Assesment of variability was based on different morphological characters showed significant variation within and between stands.

Newal (1989) studied variation in leaflets morphology among five populations *Caribbean cycads* (*zamia*) in florida. Variables measured were leaflet length and width leaflet length: width ratio, leaflet surface area, rachis and petiole length, number of leaflets per leaf and total leaf area. The four shade population, however the variation doesn't correspond to the putative species.

White et al. (1990) carried out the study of provenance variation of *Dalbergia sisso* Roxb. From six different provenances of Nepal. They concluded that the provenance showed the substantial differences in form and vigour. The district Kailali (Seti River) was found to be out standing sub provenance for volume production and was recommended for wide spread planting. They claimed the need of seed production and breeding programme of a tree from genetically superior natural stands.

Riemenscheider et al., (1993) studied variation among balsam poplar population. Significant variation was observed among populations. The traits like tree height, phenology and slapstick branching were associated with geographic origin.

David (1993) studied the seed size and packaging traits (Pod weight, seed weight per pod, number of seeds per pod, pod weight per seed and proportion of seed weight to total pod weight) in *Baptisia lunceolata* (Fabaceae) and found significant variation for seed weight and all packaging traits.

Fraze and Marquis (1994) studied on environmental contribution to floral trait variation in *Chamaecrista fusciculata*.

They found that variation in environmental factors explained a significant portion of the naturally occurring variation in corolla width, ovule number, ovule size anther length.

Kuriakose (1995) studied the genetic variability in east Indian lemongrass (*Cymbopogon flexuosus*). He observed wide variability for characters like grain yield, oil content, length of culms, length and breadth of lamina and colour of leaf sheath.

Oyama (1996) studied quantitative variation within and among population of *Arabis serrata*. He observed that phenotypic variation for all leaf traits was considerably lighter among rather than population. He also suggested some traits (e.g., leaf width/ leaf length ratio) were considerably less variables while other (e.g., leaf area/ petiole length ratio) were more plastic.

Dadline et al. (1996) studied variability and correlation studies in *Jasminum*. They observed 45 collections of *Jasminum grandiflorum* for yield and quality parameters under sub-tropical condition exhibited wide variation in the *Germplasm*. Significant correlation of yield with flower number and bud length was observed. Bud length and bud diameter were significantly correlated with bud shape. The flower number and bud length were found to be the most important, characters for maximizing yield in jasmine.

Joshi and Joshi (1996) studied the genecology of *Alnus nepalensis* D. Don at eleven stands at different latitude, longitude and altitude involving fifty eight trees in the forest of eastern, central and western Nepal and found vast amount of variation. The amount as

well as pattern of variation was consistent with extensive population. They stated that variation in individual traits showed consistency with the environmental and in some cases perhaps in genetic factor and both. The wood specific gravity varied in terms of latitude as well as longitude. Flavonoid variation was not observed.

Madhavan et al. (1997) studied floral morphology in wild *Hervea* and revealed two genotypes which are different from the rest, maintained at the rubber research institute of India. These variants differ in the pattern of growth, colour of the flower, presence of a disk at the base of the flower, and the morphology of the fruit. The possibility of those being intra species variants of site-specific variants and interspecific hybrids were discussed.

Sun (1997) studied the genetic variability in three colonizing orchids with contrasting mating systems. Mating systems showed that *Eulophia sinensis* is a self-compatible but pollinator-dependent outcrossing species. *Spiranthes hongkongensis* is a self-pollinating taxon and *Zeaxine strateumatica* is apomixis.

Colunga et al. (1997) studied morphological variation of Henequen (*Agave fourcroydes*) germplasm and its wide ancestor under uniform growth conditions. A statistical analysis of their patterns of morphological variation was performed as a part of broader research to provide evidence of its genetic diversity.

Shapcott (1998) studied the variation in *Acetephilia dindleyi* (Euphorbiaceae), which occurs in rain forest from Cape York to central New South Wales. Preliminary tests have shown variation

between populations, was matched by genetic variation at the enzyme and chromosome level. Taxonomic revision of this species implicated for the conservation and management.

Max et al. (1999) studied morphological variation allozyme variation in two sub species of *Dryas octopetala ssp. alaskensis* in the alpine areas of alaska. Morphological differences were greater between subspecies than among populations within subspecies. Divergence for a few morphological and life-history characters had apparently occurred in response to strong selection, but without divergence at allozyme loci.

Yitai et al., (1999) carried out study on phenotypic variation including growth performance, morphological and other characters such as peduncle length, shape and size of strobile, 1000 seed weight, wood density, colour of increment core and bark type from 21 locations. They observed significant variation within and among population.

Sweetapple and Nugent (1999) studied provenance variation in *Fructisia* (*Fuchsia exorticata*) on relation to palatability. They suggested that phenotypic and situational difference rather than genetic variation between the six provenances may help explain observed regional differences in *Fuctisia* health. They observed leaf chemistry, leaf, morphology, growth rate and palatability to capture possums were compared.

Ayres and Ryan (1999) studied genetic diversity and structure of the narrow endemic *Wyethia reticulate* and its congener *W.*

*Bolanderi* (Asteraceae) using RAPD and allozyme techniques. They determined colonial diversity, population size, genetic variation and spatial and genetic structure for each species.

Parki et al., (1999) studied genetic and morphological divergence in Korean *Euphorbia ebracteolata* (Euphorbiaceae). They analyzed six populations for 10 isozyme loci and 19 morphological characters. The morphological variation do not support the recognition of *E. ebracteolata* var. *coreana*. The pattern of isozyme variation strongly support the separation of such plant from remaining population of *E. ebracteolata*.

Bennet (2000) carried out the genetic variation of five species of *Trifolium* L. from southwest Turkey by analyzing genetic variation with and among species inelevan morphological and flowering characters. They found that the genetic diversity was related to climatic and adaphic factor. They found the most significant sources of variation to be related to geographical distribution.

Isik and Mckend (2000) studied provenance variation and provenance site interaction in *Pinus brutia* forty nine provenances of *Pinu brutia* were tested, 13 sites in Turkey and 10 years results were evaluated and found that there were evaluated and found that there were highly significant difference among the provenance height and diameter. The fastest growing provenance had up to 55% greater height and 50% greater diameter.

Pokhrel (2000) tested the antimicrobial activity of 20 different plants including B-cikuata were studied against eight different pathogenic organisms viz. *Bacillus subtilis* (ATCC 6635), *E. Celi* (ATCC 25922), *Pseudomonas aeruginosa*, *Staphylococcus aureus* (ATCC 2943), *Vibrio cholerae* and *Candida albicans*.

Irwin (2000) observed morphological variation and female reproductive success in two sympatric *Trillium* species. He found significant phenotypic variation in morphological characters within and among five population studied. He also claimed that morphological characters like leaf length, leaf width, stem height and stem diameter were positively correlated.

Lynn and Waldren (2001) studied morphological variation in population of *Ranunculus ripens* from the temporary limestone lakes in the west of Ireland. From the experiment it was found that the index of adult leaves were genetically based and highly heritability. Intermediate leaf resulted from gene flow between the broad and dissected leaved population.

Ojeda et al. (2001) studied the evaluation of variability in natural populations of piperina [*Minthostachys mollis* (Kunth.)] and concluded that the plants growing in different provenances showed considerable variation in morphological characters like tree height and leaf characters.

Pandey (2002) studied the geneecology of *Mentha spicata* L. in six different places of central and western Nepal. Statistical analysis

(f-distribution) showed significance variations in many parameters where as variation in flavonoid was not observed.

Tiwari (2002) studied the provenance variation of *Lastanopsis indica* (Roxb.) miq. in nine provenance of central Nepal. Variations in morphological characters of sixty-two trees and flavonoids composition were studied. Almost all morphological traits showed significant difference among provenances whereas flavonoid compound did not show geographical trend in their RF value irrespective to their morphological difference.

Yadav (2002) studied the provenance variation of *Myrica esculenta* Buch.-Hem. Ex.D.Don through out Nepal (1000-2100m) in six provenance of central Nepal. Almost all morphological traits showed significant difference among provenances whereas flavonoid compound did not show geographical trend in their RF values irrespective to their morphological differences.

Dodd and Helenurm (2002) studied genetic diversity in *Delphinium variegatum* (Ranunculaceae). The comparison of two insular endemic subspecies and their widespread mainland relative were studied. Electrophoretic data for 19 loci were collected from seven population of the main land sub species and all 24 known population of two insular endemic subspecies.

Subedi (2003) studied genecology of *Arundina graminifolia* D.Don Hochr (orchidaceae) in relation to habitat in central Nepal. Morphological traits such as plant height, leaf length, leaf width,

corolla length and pollen viability showed significant variation among population.

Ryu et al. (2004) studied variation of growth performance, timing of leaf and leaf form among 23 provenance of *Quercus rubra* L. in Korea. They found significant variation only in the petiole length, minimum width of leaf and leaf area. Longitude of seed origin was not correlated with all leaf characters while latitude was negatively correlated with vein number and positively correlated with minimum width of leaf.

Raskoti (2004) studied phenotypic variation of *Swertia chirayata* (Roxb. Exfleming) Karsten, in eastern and central Nepal. The morphological characters such as plant height, branch and leaf width showed significant variation.

Bhatta (2004) studied infraspecific variation of *Euphorbia hirta* L. in different parts of central and western region of Nepal. Quantitative traits such as leaf length, leaf breadth, length of petiole and circumference of stem and qualitative traits such as pigmentation, hairyness and development patterns showed significant variation.

Luo, et al (2005) investigated the phylogenetic relationship within Aconitum subgenus Aconitum, which is well known for its taxonomic complexity. Aconitum based on the morphology of seeds and of petals, suggesting that seed and petal morphology may reflect well the phylogenetic relationship within the subgenus, but other

morphological characters which have long been previously considered to be of important systematic value.

Tyler, T. (2005) studied the patterns of allozyme variation in 101 clones representing most of the morphological variation found in the amphi-apomictic genus *pilosella* Hill, in the Nordic countries. It is concluded that there is considerable gene flow among virtually all Nordic morpho-types of *pilosella* and this is considered an argument for applying a very broad species concept in this genus.

Halpem (2005) studied seed size variation within and among the species in *Lupinus perennis* (fabaceae). He observed significant variation in seed size with plant height and its fitness.

Anwar et al. (2005) analysed inter-provenance variance in the composition of *Moringa oleifera* oil seeds from Pakistan. Most of the parameters of *M. oleifera* oils indigenous of different agroclimatic regions of Pakistan were comparable to those of typical *Moringa* seeds oil reported in literature. They found that there is no significant variation of parameters taken for *M. oleifera* seeds with that at different vegetable oils.

Morata et al. (2005) determined level and patterns of genetic diversity of *Cedrus atlantica* (Pinaceae) by analyzing RAPD markers. They found that there was a significant genetic diversity within and among population.

Fisher et al. (2005) studied genetic variation within and between population of *Calviceps purpurea* identified on *Spartina* sp. in two

locations, New Jersey, USA and southern England. They found high genetic variability between groups. Similarly analysis of molecular variation (AMOVA) revealed that the genetic variability was mainly due to variations between groups rather than within groups and within population.

Smith et al. (2005) analyzed genetic variation among diploid perennial rye grass (*Lelioum perene* L.). The variables measured were herbage mass of dry matter (DM), sward surface height (SSH), bulk density, tiller density, tiller weight, length of sheath and length of leaf blade. They found significant variation for almost all characters.

Bhandari, (2005) studied phenotypic variation of *Eclipta prostrate* (L.) L. Quantative traits such as height of plant, leaf length, leaf width, diameter of stem, diameter of Head, length of internodes, length of pedices showed significant variation.

Joshi (2005) studied phenotypic variation of the species *Solanum xanthocarpum* Schrad and Wendl due to climatic and edaphic factors. The morphological characters such as plant height, leaf length, leaf width, corolla length showed significant variation among population.

### **3. Materials and Methods**

#### **3.1 Study Area**

The present investigated area covers the five district of Bagmati Seti and Mahakali zone. The samples were selected from five places of central, western, and far-western development region of Nepal.

Kathmandu district located between 27°34'13" to 27°49'12" N Latitude and 85°11'24" E to 85°43'12" E longitude. It covers an area of 395 sq. km and its altitude varies from 1372 to 2831m. consisting of sub-tropical, temperate and cool temperate climate. The sampling site Kirtipur lies at 1512m and located in the southern part of the Kathmandu valley and sample were studied at near hostel house.

Lalitpur district lies between 27°24'N to 27°41'24" N latitude and 85°12'E to 85°26'24"E longitude. It covers an area of 385 sq. km and its altitude varies from 457 to 2831m consisting of sub-tropical, temperate and cool temperate climate. Godawari is located in the southern part from the Kathmandu valley. The sampling site lies at 1900m altitude .

Bhaktapur district lies between 27°31' to 27°41' N latitude and 85°21' to 25°31' E longitude. It covers an area of 119 sq. km and it's altitude varies from 1372 to 2166m consisting of sub-tropical temperate and cool temperature climate. The sampling site lies at 1415m and is located 35 km from the main bazaar.

Doti district lies between 28°21' to 29°28'N latitude and 80°30' to 80°14' E longitude. It covers an area of 2025 sq. km. within the elevation ranging from 305 to 2430m. It consists of sub-tropical, cool-temperate and alpine climate. Silgadhi lies at 2210m altitude and sampling site located at the north part of Silgadhi main bazaar.

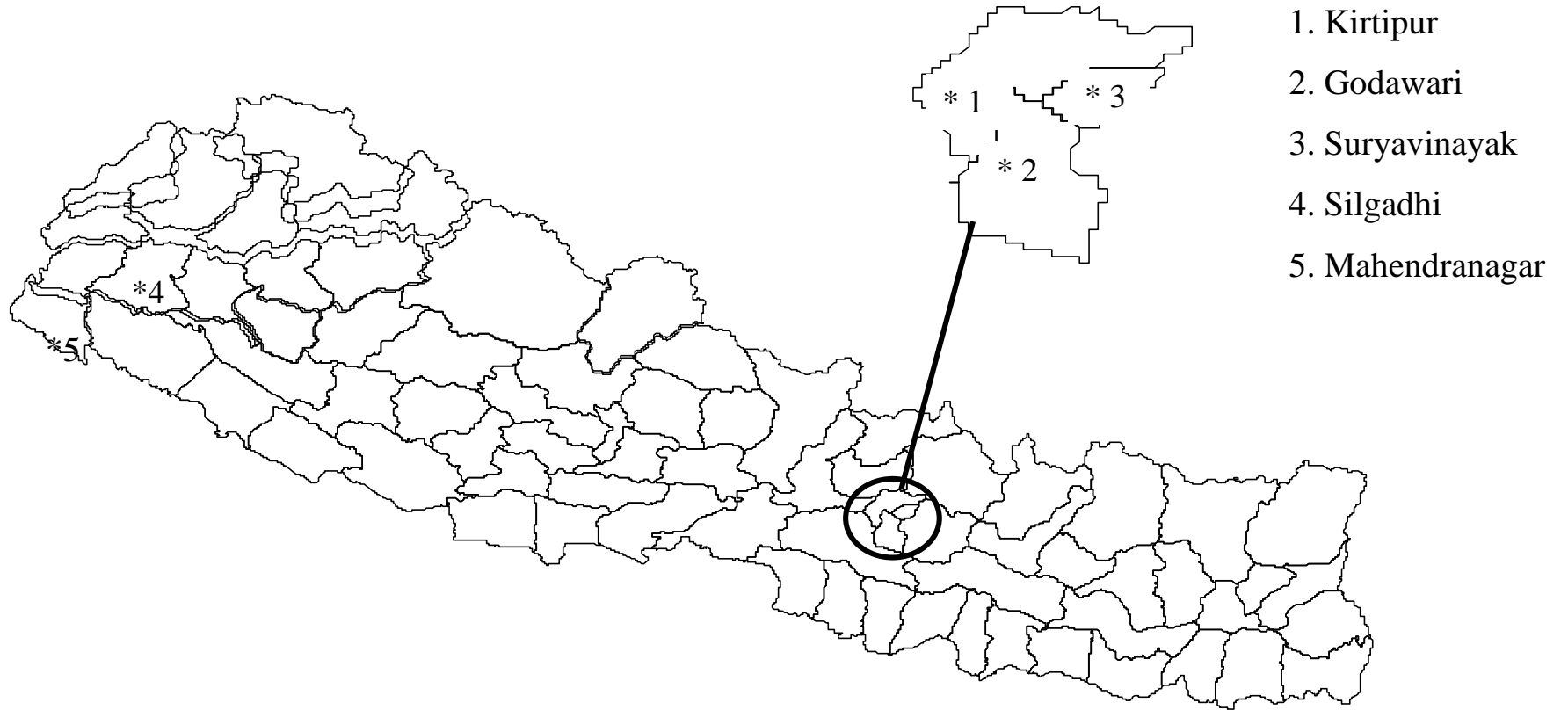
Kanchanpur district lies between 28°31' to 29°08'N latitude and 80°30' to 80°33' E longitude. It covers an area of 1610 sq. km. within the elevation ranging from 110 to 1528m. It consists of tropical and sub-tropical climate. The samples taken from the 116m altitude.

**Table No. 1: Location, Elevation and Climatic features of Study Area**

Site	District	Latitude	Longitude	Elevation	Annual Preciption (mm)	Mean Annual Temperature(°C)	
						Minimum	Maximum
Kirtipur	Kathmandu	27°41'	85°15'	1512	1392.55	12.7	25.73
Godawari	Lalitpur	27°35'	85°17'	1933	1401.31	11.9	24.12
Suryavinayak	Bhaktapur	27°39'	85°18'	1415	1223.19	12.1	25.58
Mahendranagar	Kanchanpur	28°46'	80°04'	110	1587.35	18.03	33.8
Silgadhi	Doti	28°29'	81°43'	2210	1050.2	11.2	21.86

Source: Department of Hydrology and Meterology, Kathmandu, HMG/N (2004-2005)

## Map of Nepal



**Fig. No. 2: Map of Nepal Showing Investigation Areas**

### **3.2 Survey and Sampling**

The present study carried out five natural stands of *Solanum nigrum* L. selected at different sites of central and far western region of Nepal belongs tropical and temperate region. In Central region, sites selected were Kirtipur, Suryavianayak and Godawari. Data were collected during the month of July, 2005. In far western part of Nepal, area of investigation was selected at Mahendranagar and Silgadhi. All populations were natural and had good stand quality.

Ten plants were selected randomly for the study of their phenotypic characters and variation within and among population for each site. Altogether, eight phenotypic traits were observed representative plants.

### **3.3 Data Collection**

All plants of *Solanum nigrum*L. were sampled randomly at each site with good stand quality and flowering twigs. Altogether, eight phenotypic traits were observed in representative plant are as follows:

1. Height of plant (HP)
2. Circumference of the stem (CS)
3. Leaf length (LL)
4. Leaf breadth (LB)
5. Petiole length (PeL)
6. Pedicel length (PL)

7. Sepal length (SL)
8. Petal length (PPL)

### **3.3.1 Measurement of Height of the Plant**

The height of individual plant was measured in centimeter by using flexible scale and measuring tape.

### **3.3.2 Measurement of Leaf Length and Leaf Width**

The leaf length and leaf width of the leaves were measured directly in centimeter with the help of scale. At first, maximum and minimum length and width of the leaves were measured, then their mean value were noted.

### **3.3.3 Measurement of Circumference of Stem**

Circumference of stem of each plant was measured by using thread of known length. The diameter of stem was measured by using following formula:

$$\text{Diameter} = \frac{\text{Circumference}}{\pi}$$

### **3.3.4 Measurement of Petiole Length**

Maximum and minimum length of petiole was measured in centimeter by using scale. The mean value of petiole was estimated.

### **3.3.5 Measurement of Sepal and Petal Length**

The sepal and petal length were measured directly in centimeter with the help of scale.

### **3.3.6 Measurement of Pedicel Length**

Pedicel length measured directly in centimeter with the help of scale.

## **3.4 Study of Pollen Grains**

To carry out the study of pollen grains flower buds of *Solanum nigrum* L . Were collected from different sties and preserved in 70% alcohol separately for consequence study. To check its viability anther from flower bud were removed by forceps and pollen grains were dusted over clean dry slide. There after pollen grains were stained with 2-3 drops of muntzing solution and the slide was left for 1-2 minutes and was covered with clean cover slip. The excess stain was dried out through blotting paper and observed under the compound microscope.

### **3.4.1 Apparent Pollen Viability**

The prepared slides were observed under microscope (10 x 40). The viable pollen grains were appeared dark stained, red coloured and spherical in shape which is considered as fertile pollen grains while non fertile pollen grain were appeared less stained, ruptured ,shrunked and colourless. Apparent pollen viability was calculated by using the following formula (Shakya, 2001).

$$\text{Apparent pollen viability} = \frac{\text{Total number of viable pollen grains}}{\text{Total number of pollen grain}} \times 100$$

### 3.5 Soil Analysis

Soil Samples were collected from each site i.e. Kirtipur, Godawari, Suryavinayak, , Mahendranagar and Silgadhi. The collected soil samples were taken in polythene bags with airtight and labelled. The soil parameters were analyzed at the central Department of Botany, Kirtipur. The following method applied, for testing the soil parameters are as follows:

#### 3.5.1 Moisture Content

To determine the soil moisture, 10 gm of fresh soil sample from each site was taken and dried at 80°C for 48 hours. Its final weigh was taken after cooling it. Moisture content of each soil sample were calculated by using following formula (Zobel et al. 1981):

$$\text{Moisture content of soil \%} = \frac{(b-a)-(c-a)}{(c-a)} \times 100$$

Where,

a = wt. of petridish.

b = wt. of petridish + moist soil

c = wt of petridish + dry soil after heating

(b-a) = wt. of moist soil

(c-a) = wt. of soil after heating

### 3.5.2 Water Holding Capacity (WHC)

To determine water holding capacity, collected soil samples were crushed separately with the help of mortar and pestle. There after, 10 gm of soil sample was taken in funnel equipped with filter. Some amount of water was used to saturate filter paper and this volume of water was noted. 100ml. of water was taken in a measuring cylinder and poured drop by drop on the soil with the help of pipette until the water just start to appear at the neck of funnel. The amount of water consumed by soil sample was noted.

$$\text{WHC \%} = D/W \times 100 \text{ (Zobel et al., 1987)}$$

Where D = Water retained by soil

W = wt. of soil in gm.

### 3.5.3 Organic Matter (OM)

Organic matter of soil was determined by Walkey and Black's rapid titration method (PCARR, 1980) at STSC, Lalitpur. Organic matter present in the soil was calculated by using the following formula.

$$\text{OM (\%)} = \frac{10 (S-T) \times 0.0069}{S} \times \frac{100}{\text{Wt. of soil}}$$

Where, S =ml of ferrous solution required for blank

T =ml of ferrous solution required for sample

### **3.5.4 Nitrogen (N) Content**

The total nitrogen contents of the soil was determined by Kjeldhal method (PCARR, 1980) at STSC, Lalitpur. The amount of nitrogen was determined by following formula.

### **3.5.5 Soil pH**

pH the soil was determined in a 1:1 ratio of soil sample to distilled water mixture (paste) using a glass electrode pH meter (PCARR, 1980).

## **3.6 Statistical Analysis**

Statistical analysis were conducted for each morphological traits by following ways:

1. Analysis of variance (ANOVA) within and among population were calculated for each morphological trait by using SPSS programme.
2. To determine correlation between morphological traits and the correlation is significant and not significant were performed by SPSS programme.
3. Grand mean, mean, range, standard deviation and coefficient of correlation were done through descriptive statistical analysis by using SPSS (Statistical Package for Social Scientist) programme for each individual character of 50 sampled plants in each population for all morphological traits.

#### 4. Result

The investigated sites are varying in elevation, latitude, longitude and climatic conditions belonging to different climatic zones of Nepal. The present study carried out the natural 50 population in 5 districts having different geographical variation. Usually *solanum nigrum* L. associated with *Cynadon dactylon* *Oxalis corniculata* and *Cyprus imperata* sp. but some where they were also associated with other species of plants.

Analysis of Morphological traits of *solanum nigrum* L. showed variation in within and among populations. Standard deviation and coefficient of variation are two important tools of statistical measurements to know about the dispersion of individuals around mean value and to know the measurements of relative variability of given plant within population.

Statistical analysis among population were carried out and tabulated which reflects the mean of each character, their range, standard deviation and coefficient of variation in percentage. Expression like standard deviation plants to plants. Variability indicates the dispersion of individuals around mean while coefficient of variation expressed as a percentage represents the measure of relative variability of a give traits in different sites.

## 4.1. Descriptive Statistics

### 4.1.1. Height of the Plant (HP)

The highest mean of plant height was observed in Silgadi site (63.22cm) with range of 40 to 84 cm followed by Kirtipur site. The lowest mean was observed in Godawari site (22.05cm) with the range of 11 to 33 cm The average mean of the plant height was 44.57cm. The highest CV for height of plant was observed in Kirtipur site (32.67%) whereas the least CV was observed in Suryavinayak site (14.31%).

**Table no 2: Statistical analysis for Height of the plant (HT) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	32.80	98.00	56.43	339.96	18.43	32.67
2	Godawari	11.00	33.20	22.05	47.892	6.920	31.38
3	Suryavinayak	22.80	38.00	29.74	18.118	4.256	14.31
4	Silgadi	40.30	84.00	63.22	192.46	13.87	21.94
5	Mahendranagar	32.50	62.20	51.43	76.840	8.765	17.04
	Average			44.57			

### 4.1.2 Circumference of Stem (CS) cm

The highest mean of circumference of stem was observed in Silgadi site (3.43cm) with range of 2.60 to 4.00 cm followed by Kirtipur site. The lowest mean was observed in Mahendranagar site (2.11cm) with the range of 1.60 to 3.00 cm. The average mean of circumference of stem was 2.6cm. Highest CV for circumference of

stem was observed in Godawari site (22.11%) whereas the least CV was observed in Kirtipur site (11.71%).

**Table no 3 : Statistical analysis for circumference of stem (CS) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	2.20	3.50	2.920	0.177	0.342	11.71
2	Godawari	1.50	3.00	2.170	0.231	0.480	22.11
3	Suryavinayak	1.80	3.00	2.380	0.155	0.393	16.51
4	Silgadi	2.60	4.00	3.430	0.240	0.490	14.28
5	Mahendranagar	3.00	3.00	2.110	0.517	0.268	12.70
	Average			2.600			

#### 4.1.3 Leaf Length (LL)cm

The highest mean of leaf length was observed in Mahendranagar site (10.80cm) with range of 7.60 to 14.00 cm followed by Silgadi site. The lowest mean was observed in Kirtipur site (5.73cm) with the range of 3.40 to 8.30 cm. The average mean of leaf length was 8.21cm Highest CV for leaf length was observed in Kirtipur site (27.67%) and least CV was observed in Silgadi site (9.69%).

**Table no 4: Statistical analysis for leaf length (LL) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	3.40	8.30	5.73	2.516	1.586	27.67
2	Godawari	6.30	8.50	7.51	0.612	0.782	10.41
3	Suryavinayak	5.40	8.30	6.70	0.742	0.861	12.85
4	Silgadi	8.40	11.8	10.3	1.002	1.001	9.690
5	Mahendranagar	7.60	14.0	10.8	4.273	2.067	19.13
	Average			8.21			

#### 4.1.4 Leaf Breadth (LB) cm

The highest mean of leaf breadth was observed in Mahendranagar site (8.49cm) with range of 6.50 to 10.2 cm followed by Silgadi site. The lowest mean was observed in Kirtipur site (5.43cm) with the range of 4.00 to 7.00 cm. The average mean of leaf breadth was 7.12cm. Highest CV for leaf breadth was observed in Kirtipur site (20.57%) and least CV was observed in Silgadi site (10.24%).

**Table no 5: Statistical analysis for Leaf Breadth (LB) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	4.00	7.00	5.43	1.249	1.17	20.57
2	Godawari	5.50	8.00	6.49	0.634	0.79	12.26
3	Suryavinayak	5.40	8.00	6.75	0.836	0.91	13.54
4	Silgadi	7.40	10.1	8.44	0.749	0.86	10.24
5	Mahendranagar	6.50	10.2	8.49	2.114	1.45	17.12
	Average			7.12			

#### 4.1.5 Statistical analysis for Pedicel Length (PL) cm

The highest mean of pedicel length was observed in Mahendranagar site (5.63cm) with range of 4.80 to 6.60 cm followed by Silgadi site. The lowest mean was observed in Suryavinayak site (3.24cm) with the range of 2.70 to 4.0 cm. The average mean of pedicel length was 4.29cm. Highest CV for pedicel length was observed in Godawari site (23.95%) and least CV was observed in Mahendranagar site (10.07%).

**Table no 6: Statistical analysis for Pedicels Length (PL) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	2.00	5.20	4.09	0.848	0.920	22.49
2	Godawari	2.10	5.00	3.34	0.640	0.800	23.95
3	Suryavinayak	2.70	4.00	3.24	0.196	0.442	13.64
4	Silgadi	4.00	6.20	5.18	0.608	0.780	15.05
5	Mahendranagar	4.80	6.60	5.63	0.322	0.567	10.07
	Average			4.29			

**4.1.6 Petiole Length (PeL) cm**

The highest mean of petiole length was observed in Mahendranagar site (1.32cm) with range of 0.80 to 1.60 cm followed by Suryavinayak site. The lowest mean was observed in Silgadi site (1.00cm) with the range of 0.70 to 1.30 cm. The average mean of petiole length was 1.14cm. Highest CV for petiole length was observed in Kirtipur site (28.68%) and least CV was observed in Silgadi site (18.20%).

**Table no 7: Statistical analysis for Petiole Length (PeL) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	0.60	1.60	1.140	0.107	0.327	28.68
2	Godawari	0.60	1.60	1.090	0.092	0.303	27.79
3	Suryavinayak	0.80	1.60	1.180	0.066	0.257	21.77
4	Silgadi	0.70	1.30	1.000	0.033	0.182	18.20
5	Mahendranagar	0.80	1.60	1.320	0.064	0.252	19.09
	Average			1.140			

#### 4.1.7 Sepal Length (SL) cm

The highest mean of sepal length was observed in Mahendranagar site (0.38cm) with range of 0.32 to 0.42 cm followed by Silgadi site. The lowest mean was observed in Kirtipur site (0.246cm) with the range of 0.18 to 0.31 cm. The average mean of sepal length was 0.308cm. Highest CV for sepal length was observed in Godawari site (21.28%) and least CV was observed in Mahendranagar site (9.26%).

**Table no 8: Statistical analysis for Sepal Length (SL) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	0.18	0.31	0.246	0.002	0.040	16.38
2	Godawari	0.18	0.40	0.273	0.003	0.058	21.28
3	Suryavinayak	0.19	0.35	0.270	0.003	0.051	19.11
4	Silgadi	0.29	0.51	0.373	0.004	0.065	17.58
5	Mahendranagar	0.32	0.42	0.380	0.001	0.035	9.260
	Average			0.308			

#### 4.1.8 Petal Length (PPL) cm

The highest mean of petal length was observed in Mahendranagar site (1.41cm) with range of 1.10 to 1.80 cm followed by Kirtipur site. The lowest mean was observed in Godawari site (1.20cm) with the range of 0.80 to 1.60. The average mean for petal length was 1.28cm. Highest CV for petal length was observed in Godawari site (25.41%). The lowest CV was observed in Mahendranagar site (14.32%).

**Table no 9: Statistical analysis for Petal Length (PPL) cm**

S.N.	Sites	Min.	Max.	Average	Variance	S.D.	C.V. %
1	Kirtipur	0.90	1.80	1.31	0.068	0.260	19.84
2	Godawari	0.80	1.60	1.20	0.093	0.305	25.41
3	Suryavinayak	0.96	1.67	1.26	0.055	0.235	18.57
4	Silgadi	0.70	1.50	1.24	0.074	0.271	21.85
5	Mahendranagar	1.10	1.80	1.41	0.041	0.202	14.32
	Average			1.28			

#### **4.2 Analysis of variance (ANOVA)**

Analysis of variance is an important tool to determine the significance level of any phenotypic trait. The means of traits, their range, variance, p-values, have been analyzed among populations and result of one way ANOVA is summarized here (Table no 10). Similarly results of analysis of variance of phenotypic traits in ratio among populations for expressing significance of ratios are given (Table no. 11).

**Table no. 10: Analysis of Variance (ANOVA) of phenotypic traits**

Trait	Grand mean	Range	Variance	S.D.	P-value	CV %
HP	44.574	11-98	381.708	19.537	0.000**	43.83
CS	2.602	1.5-4.0	0.444	0.666	0.000**	25.59
LL	8.214	3.4-13.8	5.787	2.405	0.000**	29.27
LB	7.120	4.0-10.2	2.456	1.567	0.000**	22.00
PL	4.296	2.0-6.6	1.426	1.194	0.000**	27.79
PeL	1.146	0.6-1.6	0.078	0.279	0.122	24.34
SL	0.308	0.18- 0.51	0.006	0.075	0.000**	24.35
PPL	1.285	0.7-1.8	0.066	0.257	0.429	20.00

**Table no. 11: Analysis of variance (ANOVA) of phenotypic traits in ratio among populations**

Trait	Grand mean	Range	Variance	S.D.	P-value	CV%
HP/CS	17.450	6.60-44.54	61.418	7.836	0.000**	44.90
LL/LB	1.149	0.70-1.84	0.042	0.205	0.006**	17.84
LL/PL	1.968	0.89-3.42	0.250	0.499	0.000**	25.35
PL/PeL	3.950	2.06-7.00	1.923	1.386	0.000**	35.08
PeL/SL	3.926	1.89-7.22	1.708	1.306	0.004**	33.26
PeL/PPL	0.924	0.33-1.66	0.076	0.275	0.885	29.76
SL/PPL	0.248	0.11-0.50	0.005	0.074	0.001**	29.83

\*\* Highly significant

\* Significant at 5% level

Non-significant

### 4.3 Coefficient of Correlation

Coefficient of correlation gives the magnitude and direction of relationship between two variables. The Pearson's coefficient of correlation has been utilized to interpret whether the individual's traits are significantly or non significantly correlated with each other. Correlations between phenotypic traits are given in Table no 12.

**Table No 12: Coefficient of correlation (r) between different  
Phenotypic traits**

	HP	CS	LL	LB	PL	PeL	SL
CS	0.722 0.084						
LL	0.414 0.244	0.065 0.458					
LB	0.358 0.277	0.079 0.450	0.971 0.003**				
PL	0.790 0.056	0.272 0.329	0.839* 0.038	0.761 0.068			
PeL	- 0.100 0.436	-0.721 0.085	0.136 0.414	0.125 0.420	0.240 0.349		
SL	0.518 0.186	0.157 0.401	0.989** 0.001	0.974** 0.003	0.883* 0.024	0.137 0.413	
PPL	0.442 0.228	- 0.274 0.328	0.355 0.279	0.306 0.308	0.647 0.119	0.847** 0.035	0.407 0.248

\*\* Correlation is significant at the 0.01 level

\* Correlation is significant at the 0.05 level

**Table 13: Coefficient of Correlation (r) between different Phenotypic traits and soil characteristics.**

	HP	LL	LB	CS	SL	PPL	PL	PeL	pH	Water holding capacity	Moisture content
pH	0.219 0.636	0.013 0.978	0.185 0.691	0.312 0.496	0.684 0.885	0.175 0.702	0.039 0.900	0.138 .768			
Water holding capacity	0.875** 0.010	0.330 0.470	0.316 0.419	0.761* 0.034	0.323 0.479	0.310 0.498	0.541 0.210	0.734* 0.050	0.277 0.547		
Moistures content	0.107 0.893	0.057 0.0912	0.147 0.758	0.044 0.926	- 0.345 0.448	- 0.052 0.912	- 0.340 0.455	0.0050 0.916	0.773 0.771	0.108 0.817	
Pollen viability	0.693 0.086	0.501 0.252	0.394 0.382	0.709 0.075	0.008 0.986	0.156 0.738	0.697 0.082	0.597 0.157	0.008 0.986	0.873 0.010**	0.424 0.343

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (t-tailed).

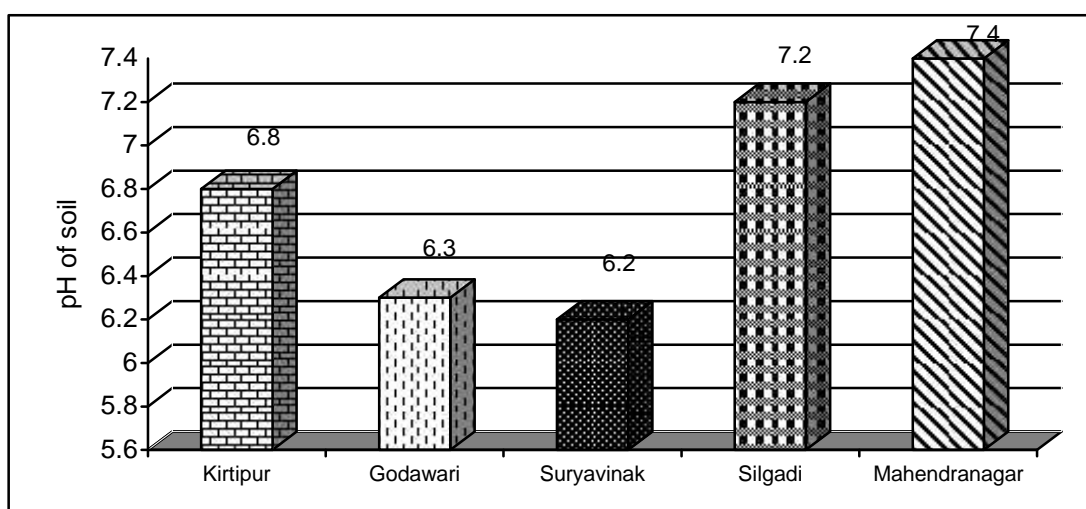
## 4.4 Edaphic factors

### 4.4.1 P<sup>H</sup>

pH of the soil ranges from alkaline to neutral to slightly acidic which ranged from 6.2 to 7.4. The soil of the site Mahendranagar (7.4) was found to be alkaline which has the most high pH among the study sites, followed by soil of Silgadi (7.2). The soil of Kirtipur (6.8), Suryavinayak (6.2) and soil of Godawari (6.3) was found to be slightly acidic.

**Table 14: pH of Soil**

S.No.	Site	PH
1	Kirtipur	6.8
2	Godawari	6.3
3	Suryavinak	6.2
4	Silgadi	7.2
5	Mahendranagar	7.4



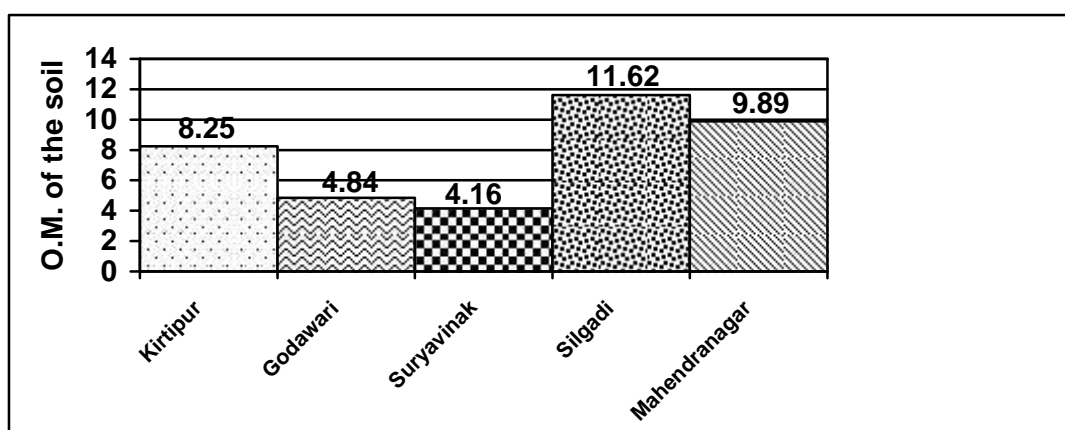
**Fig. No. 3 : pH of soil of different soils**

#### 4.4.2 Organic matter (OM)

Organic matter of the soil of different study sites were found to be ranged from 4.16 to 11.62 percent. The organic matter of the site Silgadi was found to contain most organic matters (11.62%) followed by Mahendranagar site (9.89%) while minimum amount of O.M. was found in the soil of Suryavinayak (4.16%). The organic matter of the remaining sites observed medium; Kirtipur (8.25%) and Godawari (4.84%).

**Table 15: O.M of Soil in Percentage**

S.No.	Site	O.M. %
1	Kirtipur	8.25
2	Godawari	4.84
3	Suryavinak	4.16
4	Silgadi	11.62
5	Mahendranagar	9.89



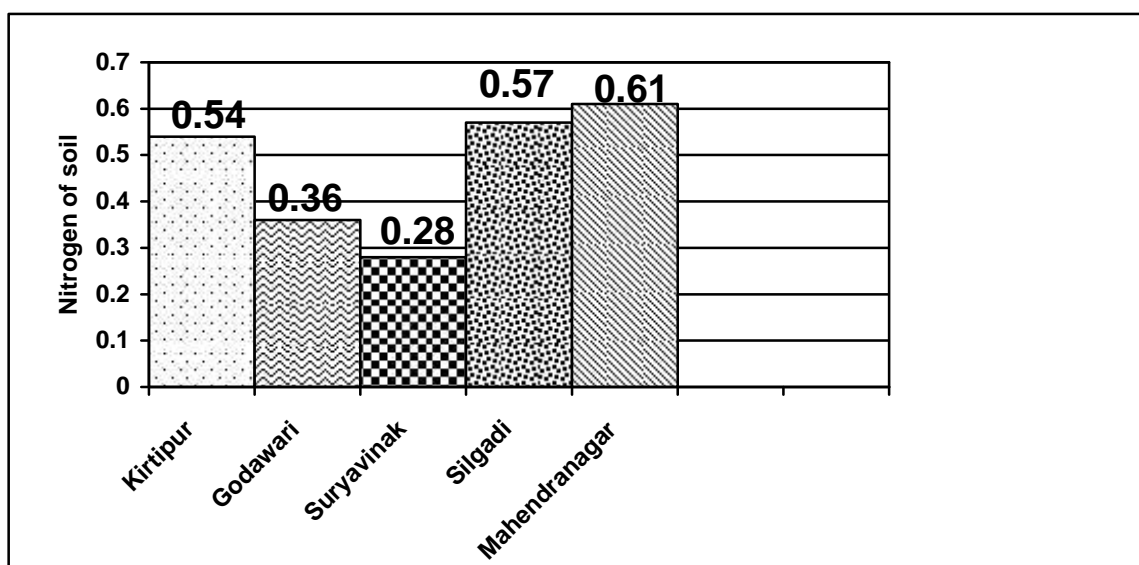
**Fig. No. 4: Organic matter of soil of different sites**

### 4.4.3 Nitrogen content (N)

Nitrogen content of the soil samples from five sites ranged from 0.28 to 0.61 Percent. The nitrogen content of the soil of Mahendranagar found highest (0.61%) followed by the soil of site Silgadi (0.57%). While the lowest amount of nitrogen was found in the soil of suryavinayak (0.28%). The nitrogen in the soil of the rest two sites found medium; kirtipur(0.54%) and Godawari (0.36%) .

**Table 16: Nitrogen of Soil**

S.No.	Site	Nitrogen %
1	Kirtipur	0.54
2	Godawari	0.36
3	Suryavinak	0.28
4	Silgadi	0.57
5	Mahendranagar	0.61



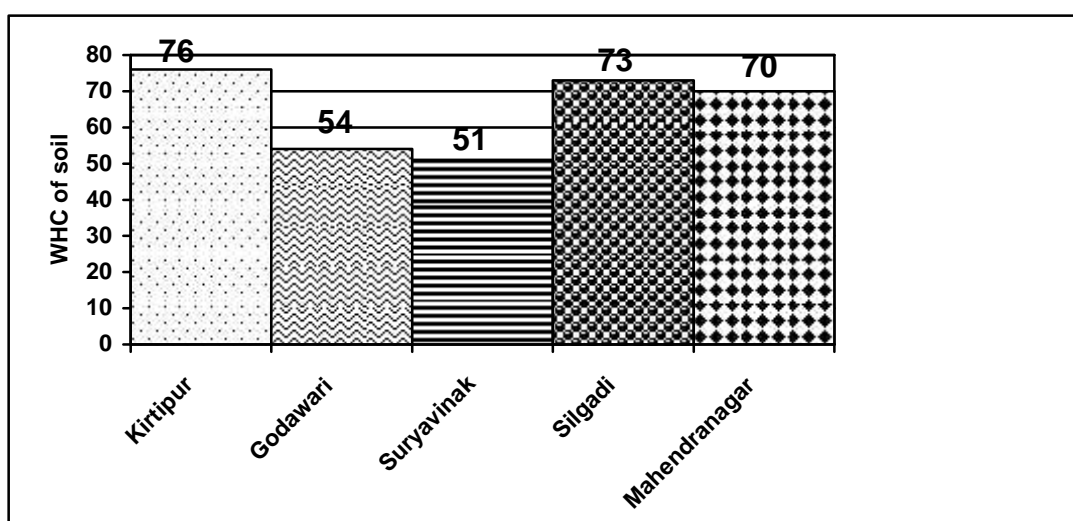
**Fig. No. 5: Nitrogen of soil of different soils**

#### 4.4.4 Water holding capacity (WHC)

From the study it was found that, the soil of Kirtipur site contained maximum Water holding capacity (76%), followed by soil of Silgadi (73%). While the soil of site Suryavinak contained least water holding capacity (51%). The water holding capacity of rest sites were medium; Mahendranagar (70%) and Godawari (54%).

**Table 17: Water holding capacity**

S.No.	Site	WHC %
1	Kirtipur	76
2	Godawari	54
3	Suryavinak	51
4	Silgadi	73
5	Mahendranagar	70



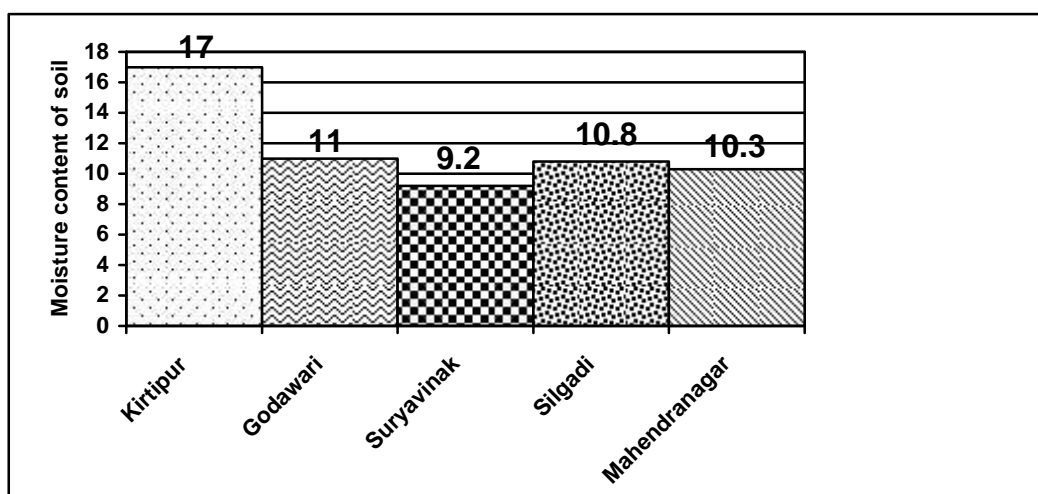
**Fig. No.6 : Water holding capacity of different soils**

#### 4.4.5 Moisture content (MC)

The two factors that are responsible for different water holding capacity are annual precipitation and water holding capacity. Among the five observed sites, the soil of Kirtipur contained highest moisture content (17%). followed by the soil of Silgadi site (10.80%). While the soil of Suryavinayak site contained least moisture content (9.2%). Rest two sites had medium moisture content; Godawari (11%) and Mahendranagar (10.3%).

**Table 18: Moisture of Soil**

S.No.	Site	M.C. (%)
1	Kirtipur	17
2	Godawari	11
3	Suryavinak	9.2
4	Silgadi	10.8
5	Mahendranagar	10.3



**Fig . No. 7: Moisture content of different soils**

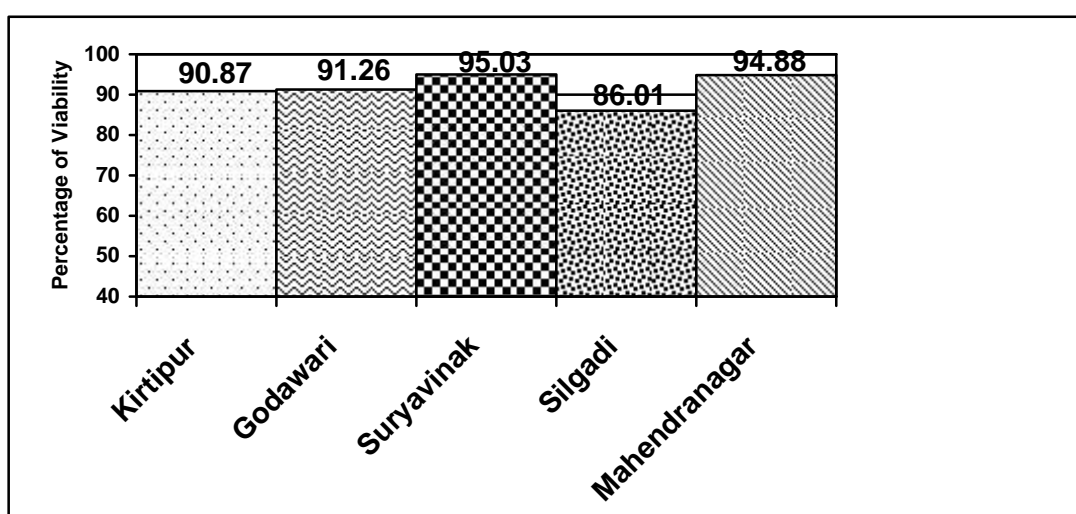
## 4.5 Pollen Grains

### Apparent Pollen Viability

Apparent pollen viability varied from 86.01% to 95.03%. The maximum apparent pollen viability was found at Suryavinayak site where as the minimum pollen viability was found at Silgadi site (Table 14). Thus the maximum population of *Solanum nigrum* L. was found at Suryavinayak site and minimum population at Silgadi site.

**Table 19: Apparent Pollen Viability of Different Sites**

S.N.	Site	Number of Pollen Grains			Viability (%)
		Viable	Non-viable	Total	
1	Kirtipur	1764	178	1942	90.87
2	Godawari	1511	145	1656	91.26
3	Suryavinayak	1545	81	1626	95.03
4	Silgadi	1692	275	1967	86.01
5	Mahendranagar	1601	87	1688	94.88



**Fig. No. 8 Pollen viability of different sites**

## 5. DISCUSSION AND CONCLUSION

### 5.1 Phenotypic Traits

The phenotypic traits showed wide range of variation among populations of *Solanum nigrum* L.. Among the phenotypic traits, eight phenotypic traits viz. variation in plant height, circumference of stem, leaf length, leaf breadth, petiole length, sepal length, petal length and pedicel length were studied.

The height of the plant showed highly significant variation among populations (Table no.10). The ratio between heights of the plant (HP) with (CS) showed highly significant variation among population (Table no.11). The height of the plant showed positive correlation with traits like circumference of stem (CS), leaf length (LL), leaf breadth (LB), pedicel length (PL), sepal length (SL) and petal length (PPL) whereas it showed negative correlation with petiole length (PeL) (table no.12). This indicates that height of the plant has strong relation with almost all traits of the plants. Irwin (2000) reported positive correlation between leaf length, leaf breadth, stem height and stem diameter within and among populations of *Trillium* species. Rebeca (2000) also found that the height of *Trillium erectum* and *T. grandiflorum* was positively correlated with leaf length and leaf width within and among populations.

Circumference of stem (CS) showed highly significant variation among populations (Table no.10). The ratio between circumferences of stem (CS) with height of plant (HP) also showed

highly significant variation among population (Table no.11). Circumference of stem showed positive correlations with traits like height of plant (HP), pedicel length (PL) while negative correlation with remaining all characters (Table no.12). Pant (2000) found significant difference of circumference within and among seven species of *Swertia* species. Rojas et al., (2000) also found stem diameter correlated positively with plant height in *Bolivan quinia* germplasm.

Leaf length (LL) also showed highly significant variation among population (Table no.10). The ratio between leaf length with leaf breadth (LB) and pedicel length (PL) also showed highly significant variation among populations (Table no.11). Leaf Length showed positive correlations with traits like circumference of stem (CS), leaf breadth (LB), pedicel length (PL), sepal length (SL) and petal length (PPL) whereas it showed negative correlation with petiole length (PeL) (Table no.12). Bhatt (2000) found that leaf length is positively correlated with all the traits in *Euphorbia hirta*.

Highly significant variation was found in leaf breadth among population. (Table.no.10). The ratio between leaf breadth (LB) and leaf length (LL) showed also highly significant variation among population (Table no. 11). Leaf breadth showed positive correlation with height of plant (HP), leaf length (LL), pedicel length (PL), sepal length (SL), and petal length (PPL) whereas it showed negative correlation with circumference of stem (CS) and petiole length (PeL) (Table no.12). Sanderson et al., (1990) also found wide variation in leaf characters of *Artiplex confertifolia*.

Petiole length (PeL) showed non significant variation among population. (Table no.10). The ratio between petiole length with pedicel length (PL) and sepal length (SL) showed highly significant variation whereas ratio between petiole length and petal length (PPL) showed non significant variation (Table no.11). The petiole length showed positive correlation with pedicel length (PeL) and petal length (PPL) whereas it showed negative correlation with remaining all characters.(Table no.12) Chandran and Pandya (2000) observed wide variation in length of lateral branches, plant width and length of petiole of the plant *Arachis* species of section *Arachis*. Medard (2000) found high variability in leaf petiole length of *Manihot esculenta* Crantz cassava classes.

Highly significant variation was found in sepal length (SL) among populations (Table no.10). The ratio between sepal length with petiole length (PeL) and petal length (PPL) also showed highly significant variation. (table no.11). Sepal length showed positive correlation with characters like height of plant (HP), leaf length (LL), leaf breadth (LB), pedicel length (PL) and petal length (PPL) whereas it showed negative correlation with circumference of stem (CS) and petiole length (PeL). (Table no.12) Subedi (2003) while studying gene ecology of *Arundina graminifolia* (D.Don) Hochr. found that sepal length is positively correlated with almost all characters positively.

Non significant variation was observed in petal length (PPL) among population (Table no.10). The ratio between petal length with petiole length (PeL) showed non significant variation while showed

highly significant variation with sepal length (SL) (table no.11). The character was found positively correlated with almost all traits showing negative correlation with only one character, circumference of stem (CS) (Table no.12).

## **5.2 Reproductive Traits**

The properties of soil like water holding capacity, moisture, temperature and high altitude affect the viability of pollen and soil with rich organic matter, better water holding capacity and warm temperature enhance good fertility of the plant (Jaishy, 2000). On the other hand genes may also control the production of fertile pollen grains. In the present study pollen viability varied from 86.01% (Silgadi) to 95.03% (Suryavinayak) (Table 19). Similar result of pollen viability was found by Mizutani et al. (2000) in *Arundina graminifolia*. The highest apparent pollen viability was found in Suryavinayak suggesting the maximum population of *Solanum nigrum L.* among studied sites. The minor reduction may occur in fertility frequency due to environmental stress like high/ low temperature, photo period and humidity (Shakya, 2001). In the present study pollen viability of *Solanum nigrum L.* showed positive correlation with all phenotypic traits and soil characteristics (Table 13)

## **5.3 Soil Characteristic**

In the present study, the soil pH ranges from 6.2 (Suryavianayak) to 7.4 (Mahendranagar) (Table 14) It has been indicated that *Solanum nigrum L.* prefers slightly alkaline and slightly acidic soil. Grasses and sedges grow under a wide range of pH, However they prefer soil in between 6 to 8 (Jaishy, 2000). Similarly, all the phenotypic traits like HP, LL, LB, CS, SL, PPL,

PL, PeL and LL showed positive correlation with pH of soil (Table 13).

Water holding capacity can be defined as the amount of water held by per unit volume of the soil. The amount of water so absorbed by the soil depends upon many factors such as soil texture, humus content of the soil etc. In the present study water holding capacity of soil ranges from 51.00 (Suryavinayak) to 76.00 (Kirtipur) (Table 17). The soil with rich organic matter contains much water holding capacity and it can hold minerals as ions by absorption and bind clay particles into aggregates. Thus, it makes clay soil porous increasing aeration of the soil and also easy percolation of water in soil (Sharma, 2003). All the phenotypic traits of *Solanum nigrum* L. showed significant positive correlation with water holding capacity of soil (Table 13).

Certain amount of water is held by every types of soil. This water is observed by plants from their roots along with dissolved minerals. The soil moistures are the total amount of water present in 100 gm of soil. In the present study moisture content of soil ranges from 9.2 Suryavinayak to 17 Kirtipur (table 18) and phenotypic traits like SL, PeL and PL showed negative correlation with moisture content (table 13).

## 6. Conclusions and recommendations

Phenotypic variation of *Solanum nigrum* L. in five natural stands consisting 50 individual plants in the different parts of Nepal has been estimated. Altogether eight phenotypic traits have been assessed in the sample plants such as height of plant, leaf length, leaf breadth, circumference of stem, sepal length, petal length, petiole length and pedicel length. Some characters like apparent pollen viability were also estimated.

At different sites of sampling analysis of variance (ANOVA) in the phenotypic traits of *Solanum nigrum* L. revealed remarkable variation among population. Wide range of coefficient of variation observed for phenotypic traits, indicating that variation exist in the population of *Solanum nigrum* L. but this variation appeared more among population than within population.

Statistical analysis of ratios of phenotypic character has been estimated in which ratios like HP / CS, LL / LB, LL / PL, PL / PeL, PeL / SL, SL / PPL showed highly significant variation whereas PeL / PPL showed non-significant variation. Similarly, significant positive correlation was found between various morphological traits. The soil characters like pH, water holding capacity and Moisture showed variation among all the five site and these characters showed both positive and negative significant correlation with different phenotypic traits.

The edaphic factor as pH, nitrogen content, organic matter, water holding capacity, and moisture content of soil showed variation among all five sites. More fertile and moist soil was found to be associated with vigorous growth of the plant. It has been found that the soil with slightly alkaline and slightly acidic properties suits the plant best.

Existence of phenotypic variation in population of *Solanum nigrum* L. may be due to environmentally controlled (ecads) or controlled by gene (ecotypes). To confirm the variation is whether genetic or environmental, it is suggested for reciprocal transplant experiment, progeny test and research on molecular level.

*Solanum nigrum* L. is the important medicinal plant of human use as it contains large number of valuable medicinal compounds of multiple use, we must give attention for conservation of this plant in its natural habitats to generate the genetic resources for future prospective in national level. Many characteristics features and properties of this species are still to be explored. Similarly, their proper management, sustainable utilization and improvement is necessary to get higher achievement from this valuable medicinal plant.

## 7 REFERENCES

Alegandro,C.,C.Javier,V.B.Alfanso,J.A.Soriana and P.Davila. 1999. Morphological variations and the process of domestication of *Stenocereus stellatus* (Cactaceae) in central Mexico. *American Journal of Botany*.86(4): 522-533.

Anonymous, 1962. A Dictionary of Indian Raw Materials and Industrial Products. Raw Materials CSIR Publ., Nepal.

Anonymous, 1980.standard methods of analysis for soil, plant tissue, water and fertilizer. PCARR and farm resources and systematic research division (FRSRD), Philipines.w Delhi, pp.358-368

Anonymous, 1999. Nepal District Profile, (4th ed.) National Research Associates., Kathmandu, Nepal.

Anonymous, 2001-2003. Climatological Records of Nepal. Department of Hydrology and Metrology, Kathmandu, Nepal.

Anwar,F.,M.Ashraf and Iqbal. 2005.Inter Provenance Variation in the composition of *Moringa oleifera* oilseeds from Pakistan.*Journal of the American Oil Chemist's Society*. 82(1): 45-51.

Atienza,S.G., Z.Satovic, A.Martin. 2005. Genetic diversity in *Hordeum chilense* Roem. et Schult. *Genetic Resources and Crop Evolution*. 52(2):127-135.

Ayres, D.R. and F.J.Ryan. 1999. Genetic Diversity and Structure of the narrow endemic *Wyethia reticulata* and its Congener *W. bolanderi* (Asteraceae) using RAPD and Allozyme techniques. *American Journal of Botany*. 86(3): 344-355.

- Bayer, R.J. 1992. Allozyme Variation, geneecology and phytogeography of *Astennaria arcuta* (Asteraceae). A rare species from Great Basin and Red desert with small disjunctive populations. American Journal of Botany. 70(8): 812-881.
- Bennett, S.J. 2002. Genetic Variation for five species of *Trifolium* L. from south-west Turkey. Genetic Resources and Crop Evaluation 47(1): 81-91.
- Bhatta, D. (2004). Intraspecific variation of *Euphorbia hirta* L. in Central and Western Nepal .M.Sc. Dissertation submitted to Central Department of Botany, T.U. Nepal.
- Bhandari, S. 2005. Phenotypic variation and its analysis in *Eclipta prostrata* (L) L.M.sc. dissertation submitted to central department of botany, Tribhuvan University, Kirtipur, Kathmandu.
- Briggs, D. and S.M. Walters. 1997. Plant Variation and Evolution. Cambridge University press, U.K.
- Chandran, K. and S.M. Pandya. 2000. Morphological characterization of *Arachis* species of section *Arachis*. Plant Genetic Resources Newsletter. 121:38-41.
- Chaudhary, R.P. 1984. Vegetation Pattern in: Majupuria ,T.C. and Kumar, R. (eds); Nepal Nature's Paradise. M. Devi .Gwalior pp.105-111.
- .Chopra, R.N., S.L. Nayar and I.C. Chopra 1958. Glossary of Indian Medicinal plants, Council of Scientific and Industrial Research (CSIR), New Delhi.

- Colunga P.G; Marin and F.M. pat.1997. Morphological variation of Henequen germplasm and its wild ancestor under uniform growth condition: Diversity and domestication. *American Journal of Botany*.84(11): 1449-1465.
- Dadline,N.K.,T.A.More and B.Singh. 1966. Variability and Correlation studies in *Jasminum*. *Indian Journal of Agriculture Science*. 30(2): 133-141.
- Darlington,C.D.and Wylie, A.P. 1955. Chromosome Atlas of Flowering plants.George allen and Unwid Ltd.Ruskin House Museum Street, London..
- David,W.M.1993. Seed size and seed packaging variation in *Baptisia lanceolata* (fabaceae). *American Journal of Botany*. 80 (7): 735-742.
- Devlin, R.M. and F.H.Witham. 1986. *Plant Physiology*. CBS Publishers and Distributors, Delhi, India.
- Dodd,S.C. and K. helenurm, 2002. Genetic diversity in *Delphinium variegatum* (Ranunculaceae): a comparison of two irregular endemic subspecies and their widespread mainland relatives. *American Journal of Botany*. 89 (4): 613-622.
- Dutt and Mukherji,\* 1950. Medicinal Drugs. *Bulletin of Pharmacognl. Laboratory*.11B,261.
- Farooqui, A.A. and B.S.Sreeramu.2001. *Cultivation of Medicinal and Aromatic Crops*. University of Agriculture Science. University Press. Bangalore, India.

- Fisher, A., T.R. Gordon and J.M. Ditomaso, 2005. Variability and correlation studies in *Claviceps purpurea* found on *Spartina* spp. Mycological Research. 109(4): 439-446.
- Frazer, J.E. and R.J. Marquis. 1994. Environmental contribution to floral traits variation in *Chamaecrista fasciculata*. American Journal of Botany. 81(2): 206-215.
- Ghauri, I.G. 1986. Physiological and bio chemical indexing of synthesis of essential oils in *Solanum* spp. Pakistan Journal of Scientific and Industrial Research. 28(6):186-192.
- Gupta, T. and R.N. Sehgal. 2000. Genetic Variability in phenotypic characters of *Toona ciliata*. Indian Journal of Forestry. 23 (4):422-427.
- Haddad, N.I. 2004. Evaluation of variation for morphological and agronomic traits in Lentils (*Lens culinaris* Medic) landrace genotypes from Jordan. Dirasat Agricultural Sciences. 31(3): 363-371.
- Halpern, S.I.L. (2005). Sources and consequences of seed size variation in *Lupinus perennis* (fabaceae). American journal of Botany, 92. 205-213.
- Hooker, J.D. 1885. Flora of British India. L . Reeve Company. Henrietta Strett, Covent Garden, London.
- Irwin, R.E. 2000. Morphological variation and female reproductive success in two sympatric *Trillium* species: Evidence for phenotypic selection in *Trillium erectum* and *Trillium grandiflorum* (liliaceae). American Journal of Botany. 87(2):205-214.

- Jaisy, S.N. 2000. Handbook of Integrated Plant Nutrients System. Soil Management Directorate, Department of Agriculture, Lalitpur, Nepal.
- Joshi, K.K. and S.D. Joshi. 1988. Studies of the genetic diversity in *Alnus nepalensis* D. Don. A project report submitted to Royal Nepal Academy of Science and Technology. (RONAST)
- Joshi M.D. 2005. Study of phenotypic variation of the species *Solanum xanthocarpum* schrad & wendl due to climatic and edaphic factors: a statistical analysis. M.Sc. dissertation submitted to central department of Botany. T.U. Kathmandu.
- Khandelwal, S.K., N.K. Gupta and B.R. 2004. Effects of Plant population densities on growth and yield of Kateli (*Solanum surattense*). Journal of Medicinal and Aromatic Plants Sciences. 26(2): 297-298.
- Kuriakose, K.P. 1995. Genetic Variability in East Indian Lemongrass (*Cymbopogon flexuosus* Staf.). Indian Perfumer. 39(2):76-83.
- Lamichhaney, B.P. 1984. Variation of *Alnus nepalensis* D. Don in Nepal. M.Sc. thesis submitted to the Board of Faculty of Biological and Agricultural Sciences. Trinity College, Oxford.
- Lawrence, H.M. 1951. Taxonomy of Vascular Plants. Oxford and IBH. Publishing Co. Pvt. Ltd. New Delhi, Calcutta. 234-259.
- Luo, Yan, Fumin Zahang and Qin-Eryang 2005. phylogeny of *Aconitum* subgenus *aconitum* (Ranunculaceae) inferred from its sequences. Plant systematics and evolution. 252 (1-2) : 11-25.

- Lynn, D.E. and B. Waldren. 2001. Morphological Variation in populations of *Ranunculus ripens* from the temporary limestone lakes in the west of Ireland. *Annals of Botany*. 87: 9-17.
- Madhavan, J., S.T. Abraham, C.P. Reghu and P.J. George. 1997. A preliminary report on the two floral variants in wild hevea germplasm collection. *Indian Journal of Natural Rubber Research*. 10(1-2):1-5.
- Marata, B.R.; S.G. Nebauer, E. Sales, J. Allainguillaume, P. Calagori and S. Sekura 2005. Genetic diversity and structure of natural and managed population of *Cedrus atlantica* (Pinaceae).
- Max, K.N., S.K. Mowchaty and K.E. Schwaegerle. 1999. Morphological and Allozyme variation of two ssp. of *Dryas octopetala* ssp. *alaskensis* in the Alpine area of Alaska. *American Journal of Botany*. 86(11): 1637-1644.
- Medard, R. 2000. The relationship between petiole length and internodes length in *Manihot esculenta* Crantz cassava clones. *Canadian Journal of Botany*. 78(1):68-76.
- Mohan, B.S. 1930. *Medicinal Drugs of India*. Vidya Wachaspati (Pb.) A.M.A.C. (Mad) research scholar, Lahore.
- Morrison, D.A. and P.H. Weston. 1985. Analysis of Morphological Variation in field sample of *Caladenia catenata* Smith Druce (Orchidaceae). *Australian Journal of Botany*. 33: 185-195.
- Neil, P.E. 1988. Preliminary Provenance testing of *Dalbergia sisoo*. *Banko Jankari*. 2(2):113-114.

- Newell, S.J. 1989. Variation in Leaflet Morphology among five populations of Caribbean Cycads (*Zamia*) in Florida. *American Journal of Botany*. 67(10): 1518-1523.
- Ojeda, M., R. Coirini, J. Cosiana, R. Zapta and J. Zygodlo. 2001. Evaluation of variability in natural population of Peperina [*Minthostachys mollis* (Kunth) Griseb], an Aromatic species from Argentina. *Plant Genetic Resources Newsletter*. 126:27-30.
- Oyama, K. 1996. Quantitative Variation within and among populations *Arabis serrata* Fr. and Sav. (Brassicaceae). *Botanical Journal of Linnean Society*. 120: 243-256.
- Pandey, D. 2002. Gene ecology of *Mentha spicata* L., M.Sc. Dissertation submitted to Central Department of Botany, T.U. Nepal.
- Pant, S.R. 2004. Genetic diversity in seven species of *Swertia* (Gentianaceae) of Nepal, M.Sc. Dissertation, submitted to the Central Department of Botany, Tribhuvan University, Nepal.
- Parki, K.R., H.J. Jung, B.T. Ahn, K.S. Lee and J.G. Kim. 1999. Genetic and morphological divergence in Korean *Euphorbia ebracteolata* (Euphorbiaceae). *Korean Journal of Plant Taxonomy*. 29(3): 249-262.
- Perks, M.P. and R.A. Ennos 1990. Analysis of genetic variation for quantitative characters between and within four natural population of Scot's pine (*Pinus sylvestris*). *Botanical Journal of Scotland*. 51(1):103-110.
- Pokhrel, N.R. 2000. screening and evaluation of the anti microbial activity of some medicinal plants of Nepal and isolation of pure

antimicrobial compounds from *Bauhinia variegata*. M.Sc. thesis submitted to central department of microbiology. T.U. Kathmandu.

Press, J.R., K.K. Shrestha and D.A.Sutton 2000. Annotated Checklist of the Flowering plants of Nepal. Natural History Museum, London.

Raskoti, B. 2004. Phenotypic Variation of *Swertia chirayta* (Roxb. Ex Fleming) Karsten in Eastern and Central Nepal. M.Sc. Dissertation submitted to Central Department of botany, T.U., Nepal.

Riday, H. and E.C. Brummer. 2004. Morphological Variation of *Medicago sativa ssp falcata* genotypes and their hybrid progeny. *Euphytica*.138(1): 1-12.

Riemenscheider, D., E.G. Bernard and M.Mahon. 1993. Genetic variations among lake state, Balsam poplar population associated with geographical origin. *Columbian Journal of Forest Science*. 39(1): 130-135.

Rojas, W.P. Barriga and H. Figueroa, 2000. Multivariate analysis of the genetic diversity in *Bolivian quinua* germplasm. *Plant Genetic Resources Newsletter*. 122: 16-23.

Ross, H.A. and J.L. Hawkins. 1986. Genetic Variation among local populations of Jackpine (*Pinus sylvestris*). *Canadian Journal of Cytology*. 28: 453-458.

Sanderson S.C., H.C. Stutz and E.D.M.C. Arthur. 1990. Geographical differentiation in *Artiplex Conifertifolia*. *American Journal of Botany*. 77(4): 490-498.

Shakya S.R. 2001. a laboratory manual of cytogenetics 2<sup>nd</sup>. central department of botany. T.U. Kathmandu.

- Shankar K. & Shrestha P.B., 1976. climate in : Majupuria, T.C. (eds.); Nepal Nature's paradise. Hillside Press Ltd. Kathmandu, pp 39-44.
- Sharma, P.D. 2001. Ecology and Environment. Rastogi Publications, Meerut, India.660p.
- Shukla,R.S. and P.S.Chandel, 1977. Plant Ecology and Soil Science(3rd ed.)S.Chand & Company Ltd. New Delhi.
- Singh,U.,A.M. Wadhvani and B.M. Johri,1983. Dictionary of Indian plants of India. Indian council of Agricultural Research, New Delhi.
- Singh,S.P., R.K. Tiwari and T.S. Dubey.1999.Selection parameter in *Mentha arvensis*. Journal of Medicine and Aromatic Plant Science. 21(1):7-8.
- Smit,H.J., B.M. Tas, H.Z. Taweel and A. Elgersma.2005. Genetic variation among diploid Perennial Ryegrass (*Lolium perennel* L.) varieties. Grass and Forage Science. 60(2):128-135.
- Subedi, S. 2003. Gene ecology of *Arundina graminifolia* D.Don. Hochr. (orchidaceae) in relation to habitat. M.Sc. dissertation Submitted to the Central Department of Botany, T.U.,Nepal.
- Sun,M.1997. Genetic diversity in three colonizing orchids with contrasting mating system. American Journal of Botany.84(2): 224-232.
- Swamy,N., R.T. Ugandhar, M. Praveen, M. Rambabu and M. Upender.2005. Induction of Streptomycin resistant plantlets in *Solanum surattense* through in vitro mutagenesis. Plant Cell and Tissue Culture. 80(2): 201-207.

- Sweetapple, P. and G Nugent. 1999. Provenance variation in *Fructicia (Fuchsia exorticata)* in relation to palatibility to possuma. *Journal of Ecology*. 23(1): 1-10.
- The Wealth of India, 1952. A Dictionary of Indian Raw Materials and Industrial Products. Raw materials vol.7., R-S council of scientific and industrial research (CSIR), New Delhi, pp., 393-394.
- Tiwari, A. 2002. Provenance variation and its Analysis in *Castanopsis indica* (Roxb.) Miq. M.Sc. Dissertation, submitted to Central Department of Botany, T.U., Nepal.
- Tyler, T. 2005. Pattern of allozymes variation in *Nordic pyloxella* plant systematics and evolution 250 (3-4) : 133-145.
- White, R.J., I. Gautam and M.Dahl. 1990. Six Nepal provenances of *Dalbergia sisoo* Roxb. *Banko Janakari*. Vol. 2, No. 4.
- Witcombe, J.R. and A.R. Rao. 1976. The Genecology of Wheat in a nepalese centre of diversity. *Journal of Ecology*. 63(3): 915-924.
- Yadav, U.P. 2002. Provenance variation and its analysis in *Myrica esculenta* Buch-Ham ex D.Don. M.Sc Dissertation Submitted to Central Department of Botany, T.U., Nepal.
- Yitai, C.L. Guiying and W.Huixiong. 1999. Study on phenotypic variation in natural range of long peduculed alder (*Alnus cremastogyne*). *Forest Research*. 12(4): 379-385.
- Zobel, D.B., M.J. Behan, U.K.R. Yadav and P.K. Jha. 1987. A practical Manual for Ecology. Ratna Book Distributors, Baghbazaar, Nepal.

## APPENDIX 1

### Primary data for phenotypic variation in *Solanum nigrum*L.

S.N	Locality	HP	CS	LL	LB	PL	PeL	SL	PPL
1	Godawari	33.2	3	7.8	5.5	2.8	1.6	0.3	1.6
2		29	2.1	8.5	6	5	0.8	0.3	0.9
3		16	1.5	8	8	3.4	0.6	0.28	0.9
4		18.5	2.8	8.2	7.2	3.1	1.1	0.27	1.4
5		21	1.9	6.5	6	4	1.5	0.4	1.5
6		28	1.8	7.2	6.4	2.1	0.9	0.18	1.6
7		11	1.9	6.3	5.8	2.8	1	0.28	0.8
8		15.8	1.9	7.2	7	3.6	1.2	0.26	1.2
9		22.6	2.6	7	7.1	3.7	1.2	0.22	1.1
10		25.4	2.2	8.4	5.9	2.9	1	0.24	1
11	Suryavinayak	28	2.8	6.3	8	2.7	0.8	0.33	0.98
12		26.4	2.6	6	7.8	2.7	1.2	0.28	1.1
13		31.3	2.1	7.2	7.2	3.3	1.4	0.24	1.25
14		32.4	2.6	5.4	7.7	3.2	0.9	0.2	1.36
15		38	1.8	8.3	6.2	4	1.1	0.19	1.5
16		26	3	6.7	5.8	2.9	1	0.27	1.48
17		22.8	1.9	6.5	5.4	3.2	1.2	0.26	1.67
18		29.6	2.5	5.9	6.8	3.4	1.1	0.35	1.12
19		32.7	2.4	7.3	6.7	3.9	1.6	0.31	0.96
20		30.2	2.1	7.4	5.9	3.1	1.5	0.27	1.23
21	Kirtipur	69.5	3.2	4.5	4.6	2	1.2	0.27	1.4
22		98	2.2	8.3	7	5.2	1.4	0.26	1.3
23		60	3.5	6.2	5.8	5	1.6	0.27	1.4
24		57.6	2.8	3.4	4.3	3.8	1	0.28	1.5
25		62.3	3.1	5.6	5.2	4.7	0.7	0.2	1
26		54.3	3	4.2	4	3.8	1.3	0.18	0.9
27		41.9	2.7	6.7	6.2	4.2	0.6	0.31	1.8
28		32.8	2.9	7.2	6.8	3.9	1.1	0.25	1.3
29		47.6	3	6.9	6.2	4.7	1	0.23	1.4
30		40.3	2.8	4.3	4.2	3.6	1.5	0.21	1.1
31	Silgadi	84	4	10.5	8.4	5.2	1.1	0.44	1.5
32		62.3	3.8	11.8	10.1	4	0.8	0.38	1.3
33		57.6	3.5	11.1	9.8	4.9	1	0.51	1.5
34		59.3	3.5	9.6	7.4	5.8	0.9	0.36	1.1
35		68.5	3.7	8.4	7.8	5.6	1.2	0.3	1.2
36		78.3	3.9	10.5	8.1	4.3	1	0.29	1.3
37		76.2	3.6	10.8	8	4.2	0.7	0.37	1.5
38		59.5	2.9	11.2	8.6	5.8	1.3	0.4	1.4
39		46.2	2.6	10	7.9	5.7	1.1	0.33	0.9
40		40.3	2.8	9.4	8.3	5.3	0.9	0.35	0.7
41	Mahendranagar	56	1.6	14	9	6.2	1.6	0.36	1.3
42		62.2	2.5	12	6.5	6.6	1.5	0.4	1.5
43		54.6	1.8	13.8	10.2	6	1.6	0.38	1.2
44		59.8	1.7	8.7	6.7	5.7	1.5	0.37	1.5
45		54.7	1.9	9.8	7.2	5.4	1.2	0.42	1.4
46		50.9	2	7.6	7	4.8	1.1	0.42	1.8
47		48.7	1.6	10.8	9.4	5.1	0.8	0.39	1.6
48		32.5	2.1	9.4	9.8	5	1.4	0.41	1.1
49		53.2	2.9	11.2	9.6	5.9	1.3	0.33	1.3
50		41.7	3	10.7	9.5	5.6	1.2	0.32	1.4

## APPENDIX 2

### Phenotypic traits in ratio among population

S.N	PPL	HP/CS	LL/LB	LL/PL	PL/PeL	PeL/SL	PeL/PPL	SL/PPL
1	1.6	11.06667	1.418182	2.785714	1.75	5.333333	1	0.1875
2	0.9	13.80952	1.416667	1.7	6.25	2.666667	0.888889	0.333333
3	0.9	10.66667	1	2.352941	5.666667	2.142857	0.666667	0.311111
4	1.4	6.607143	1.138889	2.645161	2.818182	4.074074	0.785714	0.192857
5	1.5	11.05263	1.083333	1.625	2.666667	3.75	1	0.266667
6	1.6	15.55556	1.125	3.428571	2.333333	5	0.5625	0.1125
7	0.8	5.789474	1.086207	2.25	2.8	3.571429	1.25	0.35
8	1.2	8.315789	1.028571	2	3	4.615385	1	0.216667
9	1.1	8.692308	0.985915	1.891892	3.083333	5.454545	1.090909	0.2
10	1	11.54545	1.423729	2.896552	2.9	4.166667	1	0.24
11	0.98	10	0.7875	2.333333	3.375	2.424242	0.816327	0.336735
12	1.1	10.15385	0.769231	2.222222	2.25	4.285714	1.090909	0.254545
13	1.25	14.90476	1	2.181818	2.357143	5.833333	1.12	0.192
14	1.36	12.46154	0.701299	1.6875	3.555556	4.5	0.661765	0.147059
15	1.5	21.11111	1.33871	2.075	3.636364	5.789474	0.733333	0.126667
16	1.48	8.666667	1.155172	2.310345	2.9	3.703704	0.675676	0.182432
17	1.67	12	1.203704	2.03125	2.666667	4.615385	0.718563	0.155689
18	1.12	11.84	0.867647	1.735294	3.090909	3.142857	0.982143	0.3125
19	0.96	13.625	1.089552	1.871795	2.4375	5.16129	1.666667	0.322917
20	1.23	14.38095	1.254237	2.387097	2.066667	5.555556	1.219512	0.219512
21	1.4	21.71875	0.978261	2.25	1.666667	4.444444	0.857143	0.192857
22	1.3	44.54545	1.185714	1.596154	3.714286	5.384615	1.076923	0.2
23	1.4	17.14286	1.068966	1.24	3.125	5.925926	1.142857	0.192857
24	1.5	20.57143	0.790698	0.894737	3.8	3.571429	0.666667	0.186667
25	1	20.09677	1.076923	1.191489	6.714286	3.5	0.7	0.2
26	0.9	18.1	1.05	1.105263	2.923077	7.222222	1.444444	0.2
27	1.8	15.51852	1.080645	1.595238	7	1.935484	0.333333	0.172222
28	1.3	11.31034	1.058824	1.846154	3.545455	4.4	0.846154	0.192308
29	1.4	15.86667	1.112903	1.468085	4.7	4.347826	0.714286	0.164286
30	1.1	14.39286	1.02381	1.194444	2.4	7.142857	1.363636	0.190909
31	1.5	21	1.25	2.019231	4.727273	2.5	0.733333	0.293333
32	1.3	16.39474	1.168317	2.95	5	2.105263	0.615385	0.292308
33	1.5	16.45714	1.132653	2.265306	4.9	1.960784	0.666667	0.34
34	1.1	16.94286	1.297297	1.655172	6.444444	2.5	0.818182	0.327273
35	1.2	18.51351	1.076923	1.5	4.666667	4	1	0.25
36	1.3	20.07692	1.296296	2.44186	4.3	3.448276	0.769231	0.223077
37	1.5	21.16667	1.35	2.571429	6	1.891892	0.466667	0.246667
38	1.4	20.51724	1.302326	1.931034	4.461538	3.25	0.928571	0.285714
39	0.9	17.76923	1.265823	1.754386	5.181818	3.333333	1.222222	0.366667
40	0.7	14.39286	1.13253	1.773585	5.888889	2.571429	1.285714	0.5
41	1.3	35	1.555556	2.258065	3.875	4.444444	1.230769	0.276923
42	1.5	24.88	1.846154	1.818182	4.4	3.75	1	0.266667
43	1.2	30.33333	1.352941	2.3	3.75	4.210526	1.333333	0.316667
44	1.5	35.17647	1.298507	1.526316	3.8	4.054054	1	0.246667
45	1.4	28.78947	1.361111	1.814815	4.5	2.857143	0.857143	0.3
46	1.8	25.45	1.085714	1.583333	4.363636	2.619048	0.611111	0.233333
47	1.6	30.4375	1.148936	2.117647	6.375	2.051282	0.5	0.24375
48	1.1	15.47619	0.959184	1.88	3.571429	3.414634	1.272727	0.372727
49	1.3	18.34483	1.166667	1.898305	4.538462	3.939394	1	0.253846
50	1.4	13.9	1.126316	1.910714	4.666667	3.75	0.857143	0.228571

