INTRODUCTION

Potato was unknown to the old world before the sixteenth century and at the time of discovery of America by Columbus it was not known in North and Central America. It was rather the Spanish conquistadores, who introduced potato to Europe, probably from the northern Andes, only in the later half of the sixteenth century.

The plant originated in South America, around the lake Triticaca, on the borders of Peru and Bolivia. Its cultivation has spread throughout the world from South America (Salaman, 1926).

It was brought to India by Portuguese explorers in the seventeenth century, but its cultivation spread slowly.

Major potato growing countries are USA, USSR, FRANCE, POLAND, CHINA, and Federal Republic of GERMANY.

The wild species of potatoes are distributed more or less continuously from the south of United States. The main centre of diversity is in South America in Andes between 10°N and 20°S at altitudes above 6500 ft.

A majority of the cultivars of Solanum tuberosum grown in the Andes are tetraploid (2n=48), but diploid and triploid forms are also grown. There have been two views regarding the origin of cultivated potatoes: that it might have arisen directly from an ancestral form of Solanum stenotomum Juz & Buk, by a process of simple chromosomal duplication, or that it arose as a spontaneous amphidiploid hybrid between the more ancient diploid cultivar S. stenotomum and the diploid weed, S. sparsipilum Juz & Buk. (Salaman, 1949; Simmonds, 1972; Burton, 1943).

Hawkes (1963) considered the first view more plausible. There is yet another view which hypothesises that Solanum tuberosum andigena as the ancestral subspecies of
the cultivated potato which itself perhaps descended from *S. verheir* Bitt & Wittm (a wild diploid species occurring in northwestern Argentina) following autoploidy.

Out of about 160 species of tuber bearing solanums the following are cultivated potatoes: diploids - *S. ajanhuiri* and *S. geniocalyx*, two species of triploids, one of pentaploid and a tetraploid, *S. tuberosum* (Dodds, 1962; Miller, 1972). The name *Solanum tuberosum* given to the European potato by Bauhin in 1656 was retained by Linnaeus.


It is grown in cool moist climates in temperate regions. The best temperature for tuber production is 10 to 15°C. It is grown in winters in plains. In the hilly tracts the potato is grown as a summer crop, while in the plains it is a winter crop.

In India, potato is cultivated in the West Indo-Gangetic plains. North-western and North-eastern hills and in plains in different seasons. Thus, it is possible to grow potato in our country all the year around in one part or the other. Another advantage with potato is that it can be grown in almost all types of soils except highly alkaline and saline soils.

In India, the potato has been under cultivation since its introduction during the early part of the 17th century 1615. There has been a tremendous increase in potato production in the recent times. The area under cultivation of potato in India is about 7,50,000 hectares of land more than three fourth of this is grown in the north Indian plains (Pushkarnath, 1942; Pushkarnath and Dwivedi, 1961; CIP, 1983).

The potato harvest in the area of northern plains is taken during January to March. The potato is highly perishable and
cannot be stored without refrigeration for more than two months after harvest (Kaul and Sukumaran, 1984; Nayer, 1985).

The annual production of potato in India is about 10 million tonnes. The installed refrigerated storage capacity in India is 3.5 million tonnes. If we assume that about 90 per cent of the cold storage space is available for storing potatoes, the installed capacity can hold only less than one third of the total production.

The potato is conventionally grown by vegetative propagation of seed tubers for maintenance of quality, easy establishment, vigorous growth and with no transplantation.

In a tropical country like India raising potato from seed tuber has major problems such as:

(i) High cost of tubers; (ii) Large storage space because of bulkiness of tubers; (iii) Expensive transportation; (iv) Rapid deterioration of tubers caused by storage pests and diseases; (v) Untimely sprouting if not stored in cold because of lack of adequate cold storage facilities; (vi) High energy requirement for cold storage; (vii) Transmission of viral diseases through tubers and; (viii) Drain on food reserves.

Production and use of true potato seeds have been suggested and now been established as a means of overcoming many of these problems: (i) True seeds are small; (ii) They are easy to store; (iii) Convenient to handle and easily transported; (iv) Seed being dry are less susceptible to pests, insect, fungal, bacterial and storage diseases; (v) Most importantly potato seeds do not transmit viral diseases. The requisite for true seed production is flowering and all the events leading to seed set (Maheshwari, 1950; Shivanna, 1977, 1979 and 1982; Johri, 1984; Heslop-Harrison, 1971; Bhojwani and Bhatnagar, 1995).

In India human population is highly concentrated in the northern plains (especially in the Indo-Gangetic region) where potatoes can be cultivated during the winter months but cold
storage of tubers is needed during summers. The area under potato cultivation in the hills is limited. The total yield and average yield per kg/ha/day is more in potato when compared with rice, wheat or maize but also dry matter and proteins /kg/ha/day are more than other major crops. The yield of energy and proteins from potato is 678 kg (10 kg.cal) and 176 kg respectively. In comparison food energy obtained from wheat is 394 kg/ha; rice is 68 kg; maize is 457 kg and soy, bean 525 kg.

In our country the major potato producing states are the following. (Chadha, 1994)

<table>
<thead>
<tr>
<th>State</th>
<th>Tonnes</th>
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</thead>
<tbody>
<tr>
<td>Utter pradesh</td>
<td>16,00,000</td>
</tr>
<tr>
<td>West Bengal</td>
<td>9,00,000</td>
</tr>
<tr>
<td>Bihar</td>
<td>7,00,000</td>
</tr>
<tr>
<td>Punjab</td>
<td>2,00,000</td>
</tr>
<tr>
<td>Madhya pradesh</td>
<td>1,00,000</td>
</tr>
</tbody>
</table>

The most important varieties of potato grown in our country are Kufri Kishan, Kufri Kuber, Kufri Kundan, Kufri Sindhuri, Kufri Jyoti, Kufri Badshah. All of these varieties were developed in the potato Research Institute, Shimla (Pushkernath, 1961).

Potato forms a major item of the human diet of the world’s population. Potato is claimed to be superior to every other food crop in the amount of food produced per unit area in the unit time (Weerasinghe, 1983). Interestingly, the ratio of protein to carbohydrate is far greater in potatoes than in many cereals and in the other root tuber crops. The quality of potato protein is considered to be excellent.

The potato is the most important vegetable in the world today, the tubers being cooked in various ways. It is also used for stock feed, starch, spirit and industrial alcohol. The tuber contains approximately; 80 per cent water
and 2 per cent protein and 18 per cent carbohydrate—mainly starch (Manay and Shadaksharaswamy, 1987; Purseglove, 1988; Sambamurty, 1989).

Starch is the basic component of potato tuber dry matter, providing the major amount of energy obtained by potato consumption. Before consumption, starch must be gelatinized. Starch in freshly cooked potato is rapidly digested and has low energy content than raw cereals and legumes.

Infants and small children can sustain an adequate rate of growth and maintain normal serum albumin concentration while consuming diet in which potato supplies a substantial part of both protein and energy requirement for extended period of time. It was found that upto 75 per cent of energy requirement and 80 per cent of nitrogen requirement can be met by such diet. The average biological value of potato protein is about 76 per cent of total essential amino acids to total amino acid concentration is useful to meet the needs of infants and small children.

Potato protein can be a useful weaning food in developing countries especially in varieties with higher protein contents and better carbohydrate digestibility.

Limiting factors for the consumption in diet containing increasing quantities of potato are the substantial bulk to be eaten and monotony of the diet. It has been shown that potato protein has an adequate ratio of the whole egg and is better than that of most other vegetable source. It is also comparable to cow’s milk. This is due to the fact that all amino acids are present in potato protein in comparatively large quantities because of the better balanced amino acid contents of potato protein. It is considered to be nutritionally superior to cereal proteins and is one of the few vegetable proteins comparable with highly valuable proteins of animal origin.
There are 21 amino acids in proteins of human body. Some of the amino acids e.g. methionine, threonine, lysine, valine, tryptophan, isoleucine, leucine, phenylalanine and histidine cannot be synthesized by human beings are known as essential amino and must be provided in the form of food.

Potato is also a substantial source of water soluble vitamins such as ascorbic acid, thiamin, niacin and pyridoxine and its derivatives, folic acid, pantothenic acid and riboflavin. Folic acid is an essential substance for ready absorption of iron by the human body. Potato tuber contains some minerals like iron, magnesium potassium and phosphorus.

Magnesium is another important dietary mineral. 150 g of raw potatoes provide between 6 and 10 per cent of daily requirements of magnesium and this range is likely to be the same for cooked potatoes as there is almost 100 per cent retention of the minerals in potatoes boiled in their skins.

The concentration of potassium in potatoes is high. Conversely, sodium content is low and potato is cooked unpeeled absorb less sodium chloride from the cooking water.

It is a good source of phosphorus, being similar, to other root and tuber crops. Hundred grams of boiled potato can supply 7 per cent of the daily requirement of phosphorus for both children and adults.

Potato (100g) can also provide about 83 per cent of adult and 3 per cent of child's requirement for iodine and 2 and 4 per cent of zinc requirements.

Potatoes have many other potential uses for instance, potato waste can be used to make starch as an additive in silage; potato starch is used as a filler in pharmaceutical. Potato peels are reported to be excellent for use as a dressing on burns.
Potato, normally, does not flower in the plains of India because of short days prevailing during the crop season. And by the time long day condition approaches, the crop begins to senesce. However, grafting techniques have been used for formation of flowers in potato in the plains (Juneja, 1988; Gopal and Rana, 1988).

The genotypes Kufri Jyoti and Kufri Badshah of S. tuberosum ssp, tuberosum flower profusely in northern hills as Shimla, Kufri and Kothi (13 km. from Manali). The genotype MST also flowers profusely in plains. The flowers have been found to be perfect with well developed stamens and pistil. Pollen production and fertility is satisfactory as compared to many other varieties.

Conventionally, the potato crop is raised from 'seed tuber'. Several factors associated with seed tubers are quality of seed tuber and health standard. When TPS is used as seed, the farmers can raise a successful commercial crop of potato at low cost. The present study is to produce true potato seeds in large numbers and high quality (Upadhyya et al., 1982; Juneja, 1988; Banerjee and Bhargava, 1992; Manrique, 1994).

AMINO ACIDS

The amino acids are joined together in the protein molecule by peptide bonds (-CO-NH-) formed by the condensation of the \( \alpha \)-COOH of one amino acid with the \( \alpha \)-NH₂ group of another one. Low molecular weight polymers of the amino acids are known as polypeptides. Amino acids are the basic building units of proteins. All proteins are macromolecules because of their very high molecular weights. They are the polymers - chain like molecules produced by joining a number of small units of amino acids called monomers. The general structure of amino acid:
Each amino acid is a nitrogenous compound having both acidic carboxyl (-COOH) and basic amino (-NH₂) group.

R-Symbolizes as a hydrogen atom or a methyl group or a more complex structure. All amino acids which occur in proteins belong to L-form and are all α-amino acids (Rao, 1980; Davidson, 1976; Power, 1981; Jain, 1994).

Amino acids are unlike other low molecular weight organic compounds in their properties and resemble inorganic salts. They are readily soluble in aqueous media, but only slightly soluble or insoluble in organic solvents. Their melting points are also very high as for low molecular weight organic compounds. There are twenty two amino acid which occur commonly in biological systems.

They are alanine, arginine, aspartic acid, asparagine, cysteine, cystine, glutamic acid, glutamine, glycine, histidine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylalanine, proline, threonine, tryptophan, tyrosine and valine.

**CLASSIFICATION**

There are three systems of classification of amino acid: The most used one is the following:

On the basis of the composition of the side chain or R group they may be grouped into following eight categories (Jain, 1994).

(i) **Simple amino acids:**

These have no functional group in the side chain, for example-glycine, alanine, valine, leucine and isoleucine.

(ii) **Hydroxy amino acids:**

These contain a hydroxyl group in their side chain, as
serine, threonine.

(iii) Sulphur containing amino acids:
These possess a sulphur atom in the side chain, for example cysteine, cystine and methionine.

(iv) Acidic amino acids:
These have a carboxyl group in the side chain, as aspartic acid and glutamic acid.

(v) Amino acid amides:
These are derivatives of acidic amino acids in which one of the carboxyl group has been transformed into an amide group. (-CO.NH₂) for example asparagine and glutamine.

(vi) Basic amino acids:
These possess an amino group in the side chain for example lysine and arginine.

(vii) Heterocyclic amino acids:
These amino acids have in their side chain, a ring which possesses at least one atom other than the carbon, for example tryptophan, histidine and proline.

(viii) Aromatic amino acids:
These have a benzene ring in the side chain, for example phenylalanine and tyrosine.

Table: The common amino acids found in proteins

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Abbreviation</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aliphatic</td>
<td>Glycine</td>
<td>Gly</td>
<td>H-CH-COOH</td>
</tr>
<tr>
<td></td>
<td>Alanine</td>
<td>Ala</td>
<td>CH₃-CH-COOH</td>
</tr>
<tr>
<td></td>
<td>Valine</td>
<td>Val</td>
<td>CH₃-CH-CH-COOH</td>
</tr>
</tbody>
</table>
Leucine (Leu) \( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}-\text{COOH} \)
Isoleucine (Ileu) \( \text{CH}_3\text{CH}_2\text{CH}-\text{CH}-\text{COOH} \)
Hydroxylic Serine (Ser) \( \text{CH}2\text{-CH-COOH} \)
Threonine (Thr) \( \text{CH}_3\text{-CH}_2\text{-CH}-\text{COOH} \)
Sulphur Cysteine (Cys) \( \text{HS-CH}_2\text{-CH-COOH} \)
Cystine (Cys-Cys) \( \text{H}_2\text{N-CH-CH}_2\text{-S-S-CH}_2\text{-CH}_2\text{-CH}_2\text{-COOH} \)
Methionine (Met) \( \text{CH}_3\text{-S-CH}_2\text{-CH}_2\text{-CH}-\text{COOH} \)
Acidic Aspartic acid (Asp) \( \text{HOOC-CH}_2\text{-CH-COOH} \)
Glutamic acid (Glu) \( \text{HOOC-CH}_2\text{-CH}_2\text{-CH-COOH} \)
Basic Lysine (Lys) \( \text{H}_2\text{N-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}-\text{COOH} \)
Arginine (Arg) \( \text{H}_2\text{N-C-NH-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}-\text{COOH} \)
Aromatic and Phenylalanine (Phe) \( \text{CH}_2\text{-CH-COOH} \)
Tyrosine (Tyr) \( \text{HO-CH}_2\text{-CH-COOH} \)
Tryptophan (Try) \( \text{C-CH}_2\text{-CH-COOH} \)
PROTEINS

Proteins are the most abundant macromolecules of the living cell and make a large part of the structure of the cell excluding cell wall. Proteins also occur in great variety—hundreds and thousands of different kinds may be found in a single cell.

Proteins have many different biological roles since they are the molecular instruments through which genetic information is expressed (Devlin, 1991) and as enzymes they are used by all biological reaction as biological catalysts.

The proteins, whose name means "first" or "foremost" (Lehninger, 1987). The units of protein structure and simple peptides, consist of a few amino acids joined by peptide bonds. The structure of proteins, which consist of polypeptides, are extremely long chains of many amino acid units.

Proteins are therefore polymers of amino acids which are linked to each other as

\[
\begin{align*}
\text{H} & \quad \text{H}_2\text{O} \\
\text{H}_2\text{N}-\text{C}-\text{CO}-\text{NH}-\text{C}-\text{CO}- & \\
\text{R}_1 & \quad \text{R}_2
\end{align*}
\]
The constituent elements of proteins are carbon: 54 per cent, hydrogen: 7 per cent, oxygen: 38 per cent and nitrogen: 0.003 per cent and very rarely sulphur. Presence of sulphur depends upon sulphur containing amino acid group. In certain complex proteins.

It is noteworthy that all proteins are made from the same set of 20 amino acids (which are naturally occurring) but they differ in the sequence of their amino acid units. (Morrison and Bayal 1973) Many proteins such as the enzymes ribonucle-ase and chymotrypsinogen, contain only amino acids and no other chemical groups; they are called simple proteins. Other kinds of proteins yield on hydrolysis some other chemical component in addition to amino acids; these are called conjugated proteins (Lehninger, 1987). The nonamino acid part of a conjugated proteins is usually called as prosthetic group (Morrison and Bayal, 1973; Lehninger, 1987; Devlin 1991).

Conjugated proteins are classified on the basis of the chemical nature of their prosthetic group. Lipoproteins contain lipids, glycoproteins contain sugar groups and metalloproteins contain one or the other specific metal, such as iron, copper or zinc. Usually the prosthetic group of a protein plays an important role in biological function.

**CLASSIFICATION**

Broadly the proteins are classified as below:

```
Proteins:
  /   |
 /    |
Fibrous| Globular
  
  Simple Conjugated  Simple Conjugated
```
Protamins  Globuline  Metalloproteins
Histones  Glutelins  Glycoproteins
Albumins  Prolamines  Lipoproteins

GLOBULAR CONJUGATED PROTEINES ARE FURTHER CLASSIFIED AS FOLLOWING

FIBROUS PROTEINS -
Polypeptide chains of which are arranged in long strands or sheets.

GLOBULAR PROTEINS -
Polypeptide chains of which are tightly folded into a spherical or globular shape.

GLUTELINS -
Glutenin is an example of a glutelin protein from wheat and other example would be oryzenin from rice.

PROLAMINES -
Examples are zein of maize, gliadin of wheat, rye and hordein of barley.

ALBUMINS -
The β-amylase of barley is a good example of an albumin.

HISTONES
These have been found in cell nuclei and may be associated with nucleic acids.

GLOBULINS -
Many examples of globulins may be found in the storage proteins of seeds.
### Conjugated Proteins

<table>
<thead>
<tr>
<th>Class</th>
<th>Prosthetic Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipoproteins</td>
<td>Lipids</td>
</tr>
<tr>
<td>Glycoproteins</td>
<td>Carbohydrates</td>
</tr>
<tr>
<td>Phosphoproteins</td>
<td>Phosphate groups</td>
</tr>
<tr>
<td>Hemoproteins</td>
<td>Heme (iron porphyrin)</td>
</tr>
<tr>
<td>Metalloproteins</td>
<td>Iron, zinc</td>
</tr>
</tbody>
</table>

#### GLYCOPEPTIDES

Glycoproteins contain small amounts of carbohydrate (less than 4 per cent) as its glyco part. The protein part is made by either serum or globulin.

#### LIPOPROTEINS

These proteins form complex with lipids. They are soluble in water but insoluble in organic solvents. They are a main constituent of biological membranes and are exemplified by lipovitellin.

#### NUCLEOPEPTIDES

These are compounds containing nucleic acid and protein especially protamines and histones.

1. Many proteins act as catalysts, thus enhancing the rate of chemical reactions, to such extents as needed by the living cells.
2. The fibrous proteins serve as components of the tissues holding the skeletal elements together.
3. The nucleoproteins serve as carriers of genetic characters and hence govern inheritance of traits.
4. Proteins also perform transport function.
5. Various protein hormones are known. These regulate the growth of plants and animals besides controlling many other physiological functions.

6. Under conditions of non-digestion and no chances for denaturation, the proteins accumulate inside the cells and produce toxicity.

**CARBOHYDRATES**

Carbohydrates are compounds made of carbon, hydrogen and oxygen. Certain members of the group also contain nitrogen and sulphur. Carbohydrates are synthesized from carbon dioxide and water in chlorophyll containing plants in the chloroplasts during the process of photosynthesis. The general formula of carbohydrate being \( C_n(H_2O)_n \).

The simpler carbohydrates are known as simple sugars. These are mostly soluble in water and sweet in taste. These compounds are named according to the carbonyl (aldehyde or ketone) group present in them. Those containing aldehyde (-CHO) group are called aldoses while those containing ketone (=CO) group are called ketoses. The carbohydrates are now a days broadly defined as polyhydroxy aldehydes or ketones and their derivatives (Boyer, et al. 1981; Lehninger, 1987; Srivastva, 1990-1991).

Carbohydrates in the form of sugar and starch represent a major part of the total caloric intake for human.

**CLASSIFICATION**

Carbohydrates are usually classified as follows:

<table>
<thead>
<tr>
<th>MONOSACCHARIDES</th>
<th>OLIGOSACCHARIDES</th>
<th>POLYSACCHARIDES</th>
</tr>
</thead>
</table>

**MONOSACCHARIDES**

Monosaccharides compounds which possess a free aldehyde (-CHO) or ketone (-CO) group and two or more hydroxyl groups. Their general formula is \( C_nH_{2n}O_{n} \).

Monosaccharides may be subdivided into many groups.
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trioses</td>
<td>Aldose</td>
<td>glyceraldehyde</td>
</tr>
<tr>
<td></td>
<td>Ketose</td>
<td>dihydroxy acetone</td>
</tr>
<tr>
<td>2. Tetroses</td>
<td>Aldose</td>
<td>erythrose, threose</td>
</tr>
<tr>
<td>3. Pentoses</td>
<td>Aldose</td>
<td>arabinose, ribose, xylose</td>
</tr>
<tr>
<td></td>
<td>Ketose</td>
<td>ribulose, xylulose</td>
</tr>
<tr>
<td>4. Hexoses</td>
<td>Aldose</td>
<td>glucose, galactose, mannose</td>
</tr>
<tr>
<td></td>
<td>Ketose</td>
<td>fructose, sarbose</td>
</tr>
<tr>
<td>5. Heptoses</td>
<td>Aldose</td>
<td>mannoheptulose, persenlose</td>
</tr>
<tr>
<td></td>
<td>Ketose</td>
<td>sedoheptulose</td>
</tr>
</tbody>
</table>

OLIGOSACCHARIDES

Disaccharides are commonest Oligosaccharides found in plant material. There are compound sugars that yield 2 to 10 molecules of same or different monosaccharides on hydrolysis. Sucrose is most important of these and consists of a molecule of glucose linked to one fructose. The general formula of di-, tri-, and tetra-, saccharides is $C_n(H_2O)_{n-1}$ and $C_n(H_2O)_{n-2}$ respectively.

Oligosaccharide is subdivided into the following groups.

1. Disaccharides-Sucrose, Lactose, Maltose, Cellobiose.
2. Trisaccharides-Rhaminose, Gentianose, Raffinose (found in sugar beet, cotton seed and some fungi).
3. Tetrasaccharides- Tetra-saccharides are usually present in plants in small amounts. Raffinose.
POLYSACCHARIDE

These are also compound sugars and yield more than 10 molecules of monosaccharides on hydrolysis. The polysaccharides found in plant tissue may serve structural or metabolic functions. The metabolic polysaccharides of importance are starch and inulin. The polysaccharides made of similar monosaccharides groups are homopolysaccharides. The ones made of different kinds of monosaccharides are termed as heteropolysaccharides. Their general formula \((C_6H_{10}O_5)_n\).

STARCH

It is the most important reserve carbohydrate in the higher plants tissue and is found in cereals, legumes, potatoes and other tuber vegetables.

Starch consists of two components amyllose and amylpectin.

AMYLOSE

The amyllose is an unbranched or straight chain of \(\alpha\)-D-glucose units with \(1-4\), glycosidic links. Amylose contains about 200-500 glucose units. Its molecular weight varies from a few thousand to about 150,000. Amylose gives intense blue black colour with iodine (IKI solution).

AMYLOPECTIN

The amylpectin is also made up of \(\alpha\)-D-glucose units but is branched structure and has in addition \(\alpha-1-6\), glycosidic bound besides \(1,4\)-glycosidic bond. Amylopectin has over 1000 glucose residues and its molecular weight is about 200,000 to 1000,000. The amylopectins gives a red to purple colour with iodine (IKI).

The ratio of amyllose to amylpectin in starch is different for different tissues and species. Starch grains differ in shapes and sizes from plant to plant. Potato starch grains are covered with thin layer of cellulose (Devlin 1966; Jain 1994).
PECTIN

Pectic substances are macromolecules that consist essentially of galacturonic acid units linked by α-glycosidic 1-4 linkages. In each case several hundred units are involved.

It is necessary to distinguish between pectin acids, pectins and protopectins. The pectin acids consist of galacturonic acid chains. Thus they are polygalacturonic acids. In the pectins some of the carboxyl groups of the galacturonic acid units are methylated. Thus, pectins are partial methyl esters of pectin acids. Finally, protopectins are insoluble pectin substances of varying composition. Probably carboxyl groups of the pectins which are still free are crosslinked by divalent metal ions, e.g. Ca\(^{++}\) and Mg\(^{++}\), and also by phosphoric acid. Protopectins are found particular frequently in the middle lamellae (Agarwal, et al., 1995).

LIPIDS

The term lipid was first used by a German biochemist Bloor in 1943 for a major class of tissue components and as food.

Lipids are esters of fatty acids and glycerol present in almost all organisms including viruses. The heterogeneous group of lipids are widely distributed throughout the plant kingdom. In plants, they are mostly present in the seeds, nuts and fruits. Lipids are relatively insoluble in water and readily soluble in organic solvents such as ether, chloroform, benzene and alcohols.

The lipids are important constituents of the diet. They provide food, highly rich in caloric value— one gram lipid produces 9.3 kilo calories of heat. It is also important because of the fat-soluble vitamins and essential fatty acids found with fat in the natural food material.

Lipids are important constituent of the biological membrane. The lipids found in membranes are sterols; spinasterol
for spinach, cabbage and oligomasterol for coconut and soybean.
Sitosterol for cereal grains and carosterols for caroten (Lehninger, 1987; Agarwal, 1995).

Broad classification of lipids -

**Lipids**

- Simple lipids
- Compound lipids
- Derived lipids

1. Fat and oils
   - Phospholipids
   - Fatty acid, alcohols, mono- and di-glycerides, terpenes and carotenoids

2. Waxes
   - Glycolipids

**SIMPLE LIPIDS**

These are esters of fatty acids and alcohols and this on hydrolysis gives fatty acids and alcohols. Some example are olive oil, corn oil, soyabean oil, soft margarine, castor oil.

**COMPound LIPIDS**

Compound lipids are esters of fatty acids and alcohols is combination with other compound and thus on hydrolysis give fatty acids, alcohol and other compounds. Some example are soyabean oil, seeds of higher plant.

**DERIVED LIPIDS**

These compounds although do not contain an ester linkage but are obtained by the hydrolysis of simple and compound lipids. Some example are *Claviceps purpurea* growing on rye plants as ergot of rye, vitamin A and D, D2, Spinach, Coconut, cereal grains, pine, peppermint, rose, lemon and eucalyptus.

**NUCLEIC ACID**

There are two kinds of nucleic acids the Deoxyribosenucleic acid (DNA) and Ribosenucleic acid (RNA).

Friedrich Miescher isolated a substance from the nuclei
of cells and named it as nuclein. These substances are quite different from the carbohydrates, proteins and fats. Later, it was found that the nuclein had acidic properties and it was renamed as nucleic acid. Nucleic acids occur in all living cells. Deoxyribose nucleic acid (DNA) is a major component of chromosome and is the genetic material of the cell. Small amount of DNA are also found associated with chloroplast and mitochondria.

Ribonucleic acid (RNA) is present in the cell cytoplasm and a little in nucleolus.

Like the protein, the nucleic acids are biopolymers of high molecular weight with mononucleotide as their repeating units just as amino acids are the repeating units of proteins. The constitution of nucleic acid are C, H, O, N and P. In almost all nucleic acids, there are approximately 15 to 16 per cent nitrogen and 9 to 12 per cent phosphorus.

Chemically nucleic acids constitute polymers of nucleotides with high molecular weights which are linked to each other by phosphodiester linkage. The nucleic acids are usually present in the cell in combination with protein that are called nucleoproteins. (Davidson, 1976; Devlin, 1991; Powar, 1981).

ENZYMES

Enzymes are proteins which catalyze a variety of reactions in the biological systems. The enzymes are present in all living cells. Summner and Myrback (1950) have beautifully defined enzymes as simple or combined proteins acting as specific catalysts.

The history of enzymes may be regarded as commencing with the work of Dubrunfont (1830) who prepared malt extract from germinating barley seeds. This extract possessed the power of converting starch into sugar (Powar, 1981).

Enzymes are the biological catalysts, which accelerate
the rate of biochemical reactions. Like catalysts, the enzymes regulate the speed and specificity of reaction without being used up but unlike catalysts they are produced by the living cells only.

CLASSIFICATION

Based on the chemical composition the enzyme have been classified into following three categories.

1. Enzymes molecule consisting of protein only e.g. Pepsin, Trypsin urease, amylase and so on.

2. Enzyme molecule containing a protein and a cation, e.g. carbonic anhydrase (containing Zn\(^{++}\) as cation), arginase (Mn\(^{++}\)) and tyrosinase (Cu\(^{++}\)).

3. Enzyme molecule containing a protein and a non protein organic compound known as prosthetic group e.g: catalase, Cytochrome C, Peroxidase, glycine oxidase, histamine, β-carboxylase, Phosphorylase etc (Jain, 1994).

According to the International Union of Biochemistry (I.U.B.)

1. The enzymes are classified first according to the general type chemical reaction they catalyse. On this basis there are six important classes.

2. Each class is further classified into several sub-classes on the type of bond split or formed, chemical group removed or transferred, or in some cases by a simple sub-classification of the general reaction type.

3. Main classes and subclasses are indicated by index numbers.

4. A third figure is used for more detailed subdivision of the subclass.

5. The serial number of the specific enzyme within its own sub-class is indicated by the fourth figure.

6. Thus, on the basis of the above points, each enzyme is given a systematic code number commonly known as enzyme commission (E.C.) number (Lehninger, 1987; Agarwal et. al, 1995).

The six main groups of enzymes are.
1. OXIDOREDUCTASE
   Some examples are Dehydrogenases, Oxidases and Catalase.

2. TRANSFERASES
   Some examples are Phosphorylase and Transaminases.

3. HYDROLASES
   Some examples are Esterases, Lipases, Phosphatases, Nucleosidases, Pepsin and Trypsin.

4. LYASES
   Some examples are Aldolases and Histidase.

5. ISOMERASE
   Some examples are Triose phosphate isomerase and Glucose phosphates isomerase.

6. LIGASES
   Some examples are Amino acid - activating enzyme and Glutamine synthetase.

ISOZYMES

Many enzymes occur in more than one molecular form in the same species in the same tissue or in the same cell. In such cases, the different form of the enzyme catalyzes the same reaction but since they possess different kinetic properties and different amino acid composition. They can be separated by appropriate techniques such as electrophoresis. Such multiple forms of the enzymes are called isoenzymes or isozymes (Srivastava, 1990-91; Devlin, 1991; Boyer et. al, 1981).

VARIOUS TECHNIQUES

CHROMATOGRAPHIC TECHNIQUES

Chromatography is a technique for separation of a mixture of substances. Separation is achieved by the distribution of substance between two phases - The stationary (such as solid and liquid) and the mobile phase.
The term chromatography is derived from the Greek meaning 'Coloured writing' and was first used by the Russian botanist Tswett.

**TYPES OF CHROMATOGRAPHY**

(A) Adsorption chromatography

(B) Partition chromatography

(A) Adsorption chromatography - It is of two kinds:

(1) column chromatography

(2) thin layer chromatography

(B) Partition chromatography - It is of three kinds.

(1) column chromatography

(2) thin layer chromatography

(3) paper chromatography

**PAPER CHROMATOGRAPHY**

It is a kind of partition chromatography and follows its principles.

This method is especially useful for the detection and separation of amino acids and sugars (Sherma and Zweing, 1971; Plummer, 1988; Sharma, 1992-93).

This technique is a type of partition chromatography in which the substances are distributed between two liquids, that is, one is the stationary liquid (usually water) which is held in the fibres of the chromatography paper and called the stationary phase. The other is the moving liquid or developing solvent, as the moving phase. The components of the mixture to be separated migrate at different rates and appear as spots at the paper.

The ratio of the distance moved by a compound to that moved by the solvent is known as the (relative front) Rf value and is more or less constant for a particular compound, solvent system and paper under carefully controlled conditions of solute concentration, temperature and pH.
The mechanics of carrying out a paper chromatographic analysis varies but the concept is the same. The various methods are.

(a) Ascending method - Where the solvent is allowed to rise by capillary action.

(b) Descending method - Where the solvent is fed to the paper from top.

(c) Horizontal or circular method

Where the plane of the paper is kept horizontal.

(d) Two-dimensional method

In this modified or improved method, the mixture of the compounds is subject to chromatography in two solvent systems, in the same sheet of paper. A square sheet of filter paper (ABCD) is used and the mixture is spotted near one corner, A. The chromatogram is developed in the direction AB in one solvent. As before the paper can be hung as such or can be rolled into a cylinder and hung, if a smaller chamber is used. After the run is complete, the paper is taken out and dried. The separation of compounds is now along the axis AB. The paper is now rotated through 90° and chromatographed in a second solvent system, in the direction AD.

**ELECTROPHORESIS**

Many biological molecules carry an electrical charge, the magnitude of which depends on a particular molecule and also the pH and composition of the suspending medium. These charged molecules migrate in solution to the electrodes of opposite polarity when an electric field is applied, and this principle is used in electrophoresis to separate molecules of different charges.

The electrophoretic mobility depends mainly on the ionizable group present on the surface of the particle.
POLYACRYLAMIDE GEL-ELECTROPHORESIS

The gel is prepared by polymerizing acrylamide (CH$_2$=CH.CO.NH$_2$) and a small quantity of cross-linking reagent, methylenebisacrylamide (CH$_2$=CH.CO.NH)$_2$.CH$_2$(bis), in the presence of a catalyst, ammonium persulphate. Tetramethylethylenediamine TEMED is also present to initiate and control the polymerization. The gel mixture is allowed to polymerize in small tubes which are sealed at the bottom with a rubber cap. A layer of water is placed on top of the gel to ensure a flat surface and also to exclude oxygen which inhibits the polymerization (Plummer, 1988).

**Type of PAGE** -

These are of two types.

(a) Gel rods (b) Gel slabs.

(a) Gel rods -

Gel rods have been used:

The gel rods are casted in glass tubes of uniform diameter which may be as thin as the capillaries. Gel rods are generally preferred when the sample volume is sufficiently large (App. 0.1 ml). The gel rods can be of two systems.

(I) CONTINUOUS OR HOMOGENOUS SYSTEM

The composition of the gel is same throughout as in non-polyacrylamide electrophoresis. Application of concentrates sample as thin and narrow band increase the resolution. But samples cannot be concentrated beyond a limit as it may cause transferring errors. Only those molecules which enter the gel can be resolved and very large molecules may not enter at all. The continuous gels are suitable for native analysis and enzymatic studies.

DISCONTINUOUS OR HETEROGENOUS SYSTEM

All kinds of gradient gels come under this category. In most popular “Disc -Page”, the pore size and pH are variable in upper and lower part of the gel.

After loading the samples the electric current is
passed and all negative charged molecules show migration towards anode.

Interaction of proteins to proteins, nucleic acids, hormones, lipids, carbohydrates substrates and enzymes may be studied by this system (Davis, 1964; Plummer, 1988; Agrawal, 1996).

COLORIMETER

Colorimeter is a device to measure the intensity and wave length of light after it has passed through as medium. In its simplest form, it consists of a light source, a filter to generate monochromatic light and a photo-cell with detector to measure the light intensities.

The cuvette containing the solvent to be used is placed on the light path. The solvent is so chosen as to have negligible absorption (optical density) at that wave length. The photo cell now measures the intensity of light. Now another tube containing the coloured substance dissolved in the same solvent is placed in the path of light. In general, the length of light path is always kept constant at 1 cm. The photo cell now measures the intensity of light transmitted through the solution after absorption (optical density).

Its intensity decreases exponentially as the concentration of the absorbing medium increase.

In photocalorimetry opposite coloured filters are used. If the colour of solution is red-orange blue or blue-green filters are used.

In photoelectric colorimeter white light passes a tungsten lamp through a slit, then a condenser lens to give a parallel beam which falls on the solution under investigation contained in an absorption cell or cuvette. The cell is made of glass with the sides facing the beam cut parallel to each other. In most cases the cells are 1 cm² and will hold 3 ml of liquid comfortably.

Beyond the absorption cell is the filter which is selected
to allow maximum transmission of the colour absorbed and a red filter is selected. The colour of the filter is therefore, complementary to the colour of solution under investigation.

The light then falls on to a photocell which generates an electrical current in direct proportion to the intensity of light falling on it. This small electrical signal is increased in strength by the amplifier, and the amplified signal passes to a galvanometer, or digital readout, which is calibrated with a logarithmic scale so as to give absorbance reading directly. The blank solution is first put in the colorimeter and the reading adjusted to zero extinction, this is followed by the test solution and the extinction is read off directly (Roberts and Whitehouse, 1976; Singh et al, 1978; Trehan, 1990; Plummer, 1988).

U. V. SPECTROPHOTOMETER

Modern spectrometers consist of a radiation source consisting of a tungsten lamp for producing visible light and a deuterium discharge lamp for producing ultraviolet radiations. These radiations are passed through a monochromator which automatically selects the required wave lengths. The monochromatic beam is split into two parallel beams one of which passes through a transparent cell containing very dilute solution of the organic compound. It is termed the sample beam. The second beam is directed through an identical cell containing solvent only. This is termed the reference beam. The intensity of the two transmitted beams are electronically compared and a plot of absorbance against wavelength is automatically recorded over the desired range.

The present work is based on the work done for the production of abundant flowers, fruits and true seeds of potato and their development; reproductive biology; pollination biology; embryology and scanning electron microscopy.

The first requirement was to procure genotypes of Solanum tuberosum ssp tuberosum that flower profusely.
For the present study following genotypes of *Solanum tuberosum* ssp *tuberosum* were collected by the courtesy of CPRI (Centre of Potato Research Institute) at Shimla and its research station at Kufri and from ICAR, Research Centre at Modipurum as genotypes Kufri Jyoti and Kufri Badshah and MST respectively.

**PREVIOUS WORK**

Studies regarding economical and commercial production of potato from true seed have been on the way especially in tropical and sub tropical countries. The work has been taken up by developing countries with such climates. (Upadhya et al., 1982; Wiersema, 1983, 1985; Mok, 1984; Fernandez and Villarreal, 1984; Monaries, 1984; Malagamba, 1988; Nandekar et al. 1995).

TPS technology is being considered as long term rather than as short term method in many Mexican countries. Fernandez and Villarreal (1984) have mentioned the TPS in various countries—Mexico, Central America and Caribbean that are still at experimental levels. At Mexico the TPS are used for hybridization purposes to erect new genotypes. The small tubers produced on the plants after germination of seeds are being used for planting purposes.

TPS in some parts of Guatemala use them for planting purpose as seeds because the farmers are allotted land of about 1 hectare.

Production for TPS have been under investigation at Horticultural Experimental Station Korea (Mok, 1984) for studies of breaking true seed dormancy by gibberellic acid for production of healthy seedlings. The TPS raised plants yielded flowers, fruits and seed as well as tuber.

Engels et al. (1984) has studied TPS production to be used for local consumption as a supplement to the traditional method to produce more
potatoes at low cost by the year 2000 A.D. The emphasis has been laid down on seedling tubers for further planting by farmers.

One of the challenges that faces TPS technology for future farmer adoption in developing countries is the need to develop production method and institutionalize delivering systems that makes quality seeds available to farmer at low price. CIP has been investigating these methods in Lima as well as throughout its regional research network (Accatino and Malagamba, 1982; Rowell et al., 1983a; Monares, 1984; Engels, 1984; Upadhye et al., 1984; Malagamba, 1988; Pandeya et al., 1990).

Histochemical studies have been performed on different organs of various plants. Certain histochemical studies have been done in members of Pteridophytes and Gymnosperms.

Study of shoot apex and its growth in Brachychiton has been done histochemically for insoluble carbohydrates (West and Gu K Kel, 1968) and total RNA and protein.

Insoluble polysaccharides, RNA, DNA, total proteins and callose were qualitatively studied in Ophioglossum during sporogenesis histochemically (Rudramuniyappa and Suvarnkhandi, 1992).

Fronssen-Verheijen and Willemse (1982) have studied histochemically the composition of saccharides, lipids, amino acids and proteins including certain enzymes showing change in pattern during ovule development in Pinus sylvestris.

Several histochemical localization for proteins, starch, lipids and insoluble polysaccharides in leaf cells and stomata of Athyrium have been reported by Malik and Bhardwaja (1992).

Admas (1953) had studied pollen tubes within the style cells of Zea mays by staining method Dionne and Spicer (1958) have given
staining technique for germinating pollen and pollen tubes.

King (1955; 1960) made pollen and pollination studies in Irish potato using Benzidine test and peroxidase activity with pollen of different taxa.

Dionne and Spicer (1958) used a technique of hydrolysing pistil at 60°C prior to study the pollen tube growth in stylar tissue.

Aslam et al. (1964) has given pollen viability test in Gossypium with tetrazolium salts and Norton (1966) has also used it for plum pollen viability.

The presence of starch, fats and reducing sugars in stigma exudates, transmitting tissues and pollen tubes growing through the transmitting tissues were studied in Solanum melangena; S. nigrum; Nyctanthes and Withania somnifera of family Solanaceae before and after pollination (Bhatnagar and Uma, 1969).

Distribution of histones, RNA and total proteins have been studied in the cells of shoot apices during transition to flowering in Datura stramonium (Corson and Gifford, 1969).

In Pyrus communis Stanley (1971) studied the effect of elution of pollen (for 15 seconds, 1 to 4 times on germination).

Distribution of DNA and RNA have been studied in Cuscuta reflexa and its host by Gupta and Rajeswari (1974).

Bell and Hicks (1976) have studied transmitting tissue in the pistil of tobacco.

Chandra and Upadhaya (1976) studied potato pollen viability and germination as effected by storage temperature.
The cells of transmitting tissue have been shown to develop thick walls and mainly pectinaceous intercellular substance in *Lycopersicon perevilanum* (Cresti et al. 1976).

The stylar exudate is present in *Lycopersicon* which showed presence of carbohydrate followed by protein formation (Cresti et al. 1976)

Histochemical localization for soluble and insoluble polysaccharides, phosphorylase and α-amylase in developing anther of *Datura alba* has been performed by Bhatia and Chopra (1976).

Distribution of insoluble total polysaccharides, proteins, nucleic acid and ascorbic acid during development of female gametophyte of *Capsicum annuum* and *Raphanus sativus* has been studied histochemically by Panchaksharappa and Prabhakar (1976).

The distributional pattern of total phenols were compared in the stigma and styles of *Gossypium hirsutum* and *Passiflora caerulea* in pre- and post-pollinated stages by Dhaliwal and Bhatia (1976).

Presence of enzymes alkaline phosphatase, esterase, α and β-galactosidase, β-glycosidase, leucine amino peptidase, Glucose-6-phosphate, dehydrogenase, α-glycerophosphate, Glutamate malate dehydrogenase in the developing embryo-sac of *Zephyranthes rosea* have been studied histochemically (Bhalla and Malik, 1976).

In certain species of the family Cruciferae distribution of polysaccharids, proteins, RNA and DNA in the tissue of nucellus and endosperm have been found in study of developing seeds (Prasad, 1976) by histochemical methods.

Changes of concentration of polysaccharides, RNA and proteins and their distribution in the tissues of ovule and
seed were observed in *Dioscorea bulbifora* (Panchaksharappa and Rananaware, 1976).

Beasley and Yermanos (1976) have studied of the viability of pollen grains of Jojaba by TTC after storage.

For nucleic acid, basic proteins and ascorbic acid (Shah and Pandey, 1977) studies during embryogenesis of *Limnophyton obtusifolium* have been done histochemically.

The distribution of total carbohydrates, mucosubstances, total proteins, histones, total lipids and DNA have been shown in gland cells of the ovary wall of *Ottelia alismoides* (Indira and Krishanamurthy, 1979).

Histochemical localization for proteins and RNA has been done in endosperm development and embryogenesis in the seeds of *Alyssum maritimum* by Prabhakar and Vijayaraghavan (1979).

Changes in the gradients of total proteins, insoluble polysaccharides and RNA have been found in the developing embryo and seedlings of *Sorghum bicolor* histochemically (Panchaksharappa and Annigeri, 1979).

Changes of concentration of insoluble carbohydrates, total proteins, RNA and DNA and their distribution in the tissue of embryo and endosperm in *Carica papaya* were studied (Periasamy and Balachandraganesan, 1979).

Presence of insoluble carbohydrates, insoluble proteins and nucleic acids in the tissue of ovary, gynophore and fruits of *Arachis hypogaea* were tested histochemically (Periasamy and Sampoornam, 1979).

In the *Zea mays* the localization of polysaccharides, histones, DNA and RNA in the tissues of embryo 24 to 48 hours after germination of seed have been studied histochemically (Philomena and Shah, 1979).

The distribution of proteins, DNA and RNA have been
shown in axillary floral morphogenesis in *Abelmoschus esculentus* (Nabeesa and Neelankandan, 1985).

Histochemical work for localization of polysaccharides proteins and nucleic acids has been done in *Cajanus cajan*, *Vigna mungo* and *V. radiata* during their seed development. (Seghal and Gandhi, 1987),

Insoluble polysaccharids, proteins, starch, lipids and cutin in stigma and style of *Withania somnifera* have been localized by Garg and Bhatnagar (1988).

Histochemical tests for insoluble polysaccharides, total proteins, DNA and RNA in the seeds of *Crotalaria retusa* and *C. Spectabilis* have been studied by Vijayaraghavan and Garg (1988).

Presence of polysaccharides total proteins and RNA in the early ontogeny of anther development and during microsporogenesis in anther of *Solanum nigrum* by Bhandari and Sharma have been studied histochemically (1987; 1988).

During anther development of *Carica papaya* Sheel and Bhandari, 1990 have studied the distribution of insoluble, polysaccharides total proteins and callose histochemically.

Histochemical localization of polysaccharids, total proteins, DNA, RNA and callose were studied in *Sesbania speciosa* during meiotic prophase by Vijayaraghavan and Seth (1991).

Alexender (1987) has given various techniques for staining pollen tubes on stigma and their entry into the style and ovary histochemically.

Bands of total proteins in the tissue of seeds in *Flax* were studied by Sammour (1989). In *Luffa* species. the band distribution of proteins in seeds have been studies electrophoretically by Singh and Roy, (1990).

Electrophoretical distribution for proteins in seeds of *Douglas fir* has been performed by Green et al. (1991).
Presence of proteins in the tissue of potato tuber and presence of protein in *Solanum tuberosum* during in vitro tuberization by nodal cuttings have been studied (Gellatly et al. 1994) and Desire, et al. (1995) respectively.

Kuhns and Fretz (1978) tested electrophoretically the presence of enzymes in Rose cultivars.

Peroxidase isozyme have been reported in the developmental stages of female and male plants of *Bursera penicillata* which revealed differential isozyme patterns by Parthasarathi et al. (1982).

Distribution of bands for peroxidase activity and phenolic substances of peduncles of rose flowers has been performed by Zieslin and Ben-Zaken (1993).

**OBJECTIVES.**

I PLANTING, RAISING AND GRAFTING OF POTATO PLANTS:

1. To grow potato plants for production of true seeds in prevailing condition of environment of Dayalbagh during growing season of potato crop.

2. To plant the seed tubers of all the three genotype (that produce profuse flowering in hills and tested in plains) on bricks as it results in healthy growth and produce large number of scions.

3. To grow tomato seedlings to be used as root stocks for potato scions.

4. Grafting of potato scions on tomato root stocks since it requires initiation of flowering, fruiting and seed production in plains. This procedure is extremely essential as this has been an established phenomenon. (Juneja, 1988)

5. To study the vegetative phase of grafted plants of potato - the behaviour of formation of stolons and aerial tubers.

6. To study the anatomy by serial microtome sectioning through the graft union produced by joining of potato scion with the incised tomato root stock.
II. STUDIES ON REPRODUCTIVE PHASE OF POTATO:
1. To compile the number of inflorescences, buds, flowers, fruit and seeds of all the plants of various genotypes raised in the field.
2. To compare the number of inflorescences buds, flowers, fruits and seeds of various genotypes raised.
3. To classify the various floral buds and flowers into different stages as markers.
4. To study the presence of number of pollen per flower.
5. To count the number of fertile and sterile pollen per flower by stainability test.
6. To study viability and germinability of pollen.
7. To note critical stages of pollen development at particular floral bud/flower stages.
8. To find out critical stages of stigma, style and ovule development at particular stages of floral bud/flower.
9. To classify three particular stages of fruit development according to their weight and volume.
10. To count the number of seeds per mature fruit.
11. To perform additive (repeated) hand pollinations over open pollination for achieving the maximum number of true seeds.
12. To procure true seeds from fruits and study their germinability and viability in the laboratory and garden conditions.
13. To sort out various embryo-types for selecting best and vigorous types of seeds.
14. To raise the potato plants from true seeds of respective genotypes under study.

III. BIOCHEMICAL STUDIES OF VEGETATIVE AND REPRODUCTIVE PHASES:
A. AMINO ACIDS:
1. To determine the types of amino acids present in various vegetative parts of potato plant.
2. To determine the occurrence of various types of amino acids in the floral parts of potato plant.

B. CARBOHYDRATES, PROTEINS AND LIPIDS-
1. Qualitative microchemical test for the presence of -
   (a) reducing sugars (b) non-reducing sugar - starch and pectin
   (c) protein (d) lipids.
2. To determine the reducing sugars and total proteins in some vegetative and reproductive parts of potato plant by quantitative analysis using microchemical tests.
3. To determine the presence of reducing sugar by quantitative estimation using photocolorimeter.
4. To determine total starch content by quantitative estimation using photocolorimeter.
5. To determine for total proteins by quantitative estimation using ‘Lowry’s method’.

IV. HISTOCHEMICAL STUDIES OF REPRODUCTIVE PHASE
1. To stain for Carbohydrates - polysaccharids: starch and pectin.
2. To stain for lipids.
3. To stain for total proteins.
4. To stain for nucleic acids -RNA and DNA.

V. POLYACRYLAMIDE GEL ELECTROPHORESIS STUDIES OF VEGETATIVE AND REPRODUCTIVE PHASES:
1. To perform experiments for separation of total proteins.
2. To perform experiments for separation of glycoproteins.
3. To perform experiments for separation of lipoprotein.
4. To perform experiments for separation of nucleic acids.

A. ENZYMOLGICAL STUDIES IN VEGETATIVE AND REPRODUCTIVE PHASES
   A. Histochemical tests for anther, pollen, stigma, style and ovary.
1. To stain the enzyme acid phosphatase.
2. To stain for the enzyme peroxidase.
3. To stain for the enzyme dehydrogenase.

B. BY POLYACRYLAMIDE GEL ELECTROPHORESIS TEST.
1. To perform experiments for peroxidase.
2. To perform experiments for catalase.
3. To perform experiments for tyrosinase.