Phenology, Morphology and Anatomy

Introduction

The largest family Amaryllidaceae under monocotyledons are consisting near about 85 genera and 1300 species which are mainly distributed in tropical and subtropical regions of the world (Willis 1973). Carolus Linnaeus established the genus *Crinum* L. in 1753. In India, the first detailed taxonomical workout of *Crinum* L. was done by William Roxburgh embedded in the Flora of India (1832), in which he recorded 14 species from British India. Subsequently, Herbert (1837) in his classical work on Amaryllidaceae included six species and four varieties of *Crinum* L. from British India. The genus is most diverse in Southern Africa (Meerow and Snijman 1998, Meerow *et al.* 2003, Sebsebe *et al.* 2003, Kwembeya *et al.* 2007). The total number of species of the genus for India raises to13, of which 8 species belong to subgenus *Platyaster* or *Codonocrinum* (having funnel-shaped perianth) and 5 species are subgenera Stenaster (having star-shaped perianth). Out of five Stenaster species *C. asiaticum*, *C. latifolium*, *C. malabaricum* and *C. viviparum* var. *viviparum* occur in Peninsular India, whereas *C. wattii* Baker is known from Assam in India and Thailand. *Crinum* L. is a pan tropical genus originated from two main centers - South America and South Africa. In India only 13 species, 1 variety and 1 form have been reported among them 5 are endemic to India (Govaerts *et al.* 2012). The plants are geophytes i.e. the propagation is mainly through vegetative means either bulbous or rhizomatous (Bjora *et al.* 2009). The *Crinum* species have commercial, economical and medicinal importance. Many species of the genus have ornamental value for their large showy and attractive flowers. A large number of natural products like alkaloids, phenolic compounds, flavonoids, glycosides etc. are found in this plant. The different

species of the genus have not only been used in pharmaceutical industries, but also used extensively as folk herbal medicines against various diseases in several countries. Plant anatomy plays as a very important role to identify proper species to avoid adulterants and also assures the quality of drugs (Mandal and Nandi 2012). Necessity of morpho-anatomical study of medicinal plants is required for its quality control of the drugs reported by the earlier workers (Bannerjee and Mookherjee 2001, Gupta et al. 2001). World Health Organization also emphasized on the microscopic and macroscopic study of medicinal plants is very much important to any study of plant product for the purpose of identification and assurance of quality control of crude drugs (Anonymous 1996). Present study deals with the phenological, morphological and anatomical diversity among different provenances of two species of *Crinum* L. which show intra and inter specific diversity among them. Three phases of Phenological study and plant height, leaf length and margin, appearance of bulbs, floral morphology along with anatomical features of leaves and roots have been worked out and discussed under the present study in an attempt to demonstrate the inter and intra-specific diversity.

Materials and Methods

Materials

The study has been dealt with two different species of *Crinum* L., namely, *C. asiaticum* and *C. latifolium*. Two different species of *Crinum* L. were collected from different parts of West Bengal and also from different states of India.

Crinum asiaticum L. was collected, as provenances, from Assam and different districts of West Bengal like, Purba Medinipur, Paschim Medinipur, Nadia, Kolkata, North 24 Pargana and Darjeeling.

Crinum latifolium L. was collected as provenances from different states of India like, Assam, Sikkim, Jammu & Kashmir, Odisha and different districts of West Bengal like Purba Medinipur, Paschim Medinipur, Bankura, Kolkata and Nadia.

Table 3.1: Name of different Provenance of *Crinum asiaticum* L.

Sl. No.	Name of Species	Location	Name of Provenance	Latitude (ºN)	Longitude (ºE)
01	*Crinum asiaticum*L.	Kolkata, West Bengal	**CAKO**	22.571	88.420
02	*Crinum asiaticum*L.	Mungpoo,West Bengal	**CAMO**	26.974	88.339
03	*Crinum asiaticum*L.	Nadia, West Bengal	**CANA**	23.265	88.436
04	*Crinum asiaticum*L.	North 24 pargana, West Bengal	**CANO**	22.135	88.401
05	*Crinum asiaticum*L.	PaschimMedinipur, West Bengal	**CAPA**	22.430	87.321
06	*Crinum asiaticum*L.	PurbaMedinipur, West Bengal	**CAPU**	21.900	87.536
07	*Crinum asiaticum*L.	Shillong, Meghalaya	**CASH**	25.581	91.887
08	*Crinum asiaticum*L.	Sundarban, West Bengal	**CASU**	21.949	89.183

Table 3.2: Name of different provenance of *Crinum latifolium* L.

Sl.No.	Name of Species	Location	Name of provenance	Latitude (ºN)	Longitude(ºE)
01	*Crinum latifolium*L.	Assam	**CLAS**	26.979	94.643
02	*Crinum latifolium*L.	Bankura, West Bengal	**CLBA**	20.574	86.798
03	*Crinum latifolium*L.	Gangtok, Sikkim	**CLGA**	27.338	88.606
04	*Crinum latifolium*L.	Kashmir	**CLKA**	33.778	76.576
05	*Crinum latifolium*L.	Kolkata, West Bengal	**CLKO**	22.571	88.420
06	*Crinum latifolium*L.	Nadia, West Bengal	**CLNA**	23.265	88.436
07	*Crinum latifolium*L.	Odisha	**CLOD**	19.314	87.794
08	*Crinum latifolium*L.	PaschimMedinipur, West Bengal	**CLPA**	22.430	87.321
09	*Crinum latifolium*L.	PurbaMedinipur, West Bengal	**CLPU**	21.900	87.536
10	*Crinum latifolium*L.	Shillong, Meghalaya	**CLSH**	25.581	91.887

Methods

Identification of plants

Two species were identified by Central National Herbarium (CNH, http://164.100.52.111/cnh/index.htm), Howrah and with the help of digital herbarium of Berlin (BGBM, http://www.bgbm.org/bgbm/research/colls/herb/default.htm).

Phenological Study

The phenological survey was conducted during the year 2014-2019 in both the species from districts of Paschim Medinipur of West Bengal. The phonological

records of two medicinal and ornamental plants *Crinum asiaticum* L. and *C. latifolium* L. had been observed in eighteen provenances from widely separated study sites. Phenological observation had been at least thrice in a month by visiting the respective field in the germplasm beds of departmental garden.

The periods of starting flowering were measured when the inflorescences were completely open and blossomed flowers were observed from all the populations. Here, the blossomed flower means flower leaves completely opened. The growth started when the buds were observed above the soil surface and the unfolding started when leaves completely open was observed for the leaf unfolding period. The fallen blossom was considered and observed when 90 -100% of leaves were withered or dead.

A phenological clock with different phenological stages were shown, where number 1 is indicate sprouting of buds in bulbs, 2.Vegetative phase, 3. Flowering phase, 4. Fruiting phase, 5. Seed maturation, 6. dyeing or death of species and P-perennation for phenological observation**.**

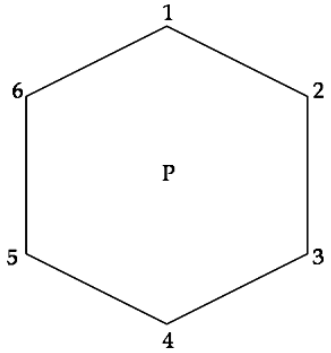


Figure 3.1: Phenological clock

Morphological study

External morphological studies of all the provenences have been carried out. The gross habit of same aged plants, plant height, phyllotaxy, leaf length and width, leaf margin, appearance of bulbs, basal part of bulbs, end part of bulbs, inflorescence type, color of flower, characters of perianth, stamens, carpels and fruits and seeds of both species of different localities were taken into an account.

Anatomical study

Anatomy of the roots and the lamina of all provenences of the both species were worked out with their respective transverse sections (T. S.) and observed under the *Leica DM 1000* microscope. These studies dealt with the type of stomata, nature of vascular bundle, number of xylem strand etc. More than seventy features have been studied here to see the relation of both the species through the dendrogram analysis. Plants of equal ages were taken in these studies to avoid the case of inequality due to age of maturity. The tissue sections were mounted in glycerol (10%) and the microscopic photographs were taken.

Statistical analysis

The numerical data were statistically analyzed with SPSS software version 22. The level of significance used in F test was P = 0.05.

Results

The morphological studies showed significant differences amongst the provenance of both species in respect of gross habit of plant, plant height, appearance of tuber, leaf length, leaf margin, perianth, filaments stamen (Table 3.3, Fig. 3.2, 3.3 & 3.4). In regard of anatomical studies of leaves the number of vascular bundle and the shape of it varied in different provenance of both species. Differences were also found in vascular bundles of the leaves. The bulb shapes of different provenances are diverse in nature (Fig. 3.1, 3.2). In the root anatomy, shape of endodermis cells, number of xylem strand and shape of xylem, presence of raphides, size of pith parenchyma cells, diameter of cortex and stele were studied here to sort out the differences among the species (Table 3.8, 3.11 Figure 3.6 to 3.22). A dendrogram has been prepared with help of different morpho – anatomical parameters of different provenance; it is shown the relationship among the different locations.

Table 3.3: Phenological features of *Crinum asiaticum* L.

Phases		**CAKO**	**CAMO**	**CANA**	**CANO**	**CAPA**	**CAPU**	**CASH**	**CASU**
Vegetative phases	**1** Bulb sprout	April	April	April-May	April	April-May	April-May	April-May	April-May
	2 Active vegetative	May-October	May-October	May-October	May-October	May-October	May-October	May-October	May-October
Reproductive phase	**3** (a) Emergence of inflorescence	June	June	June	June - July	June	May-June	June	June
	(b) Inflorescence of full bloom	July - August	March-May	March - April	August - September	March - April	March - April	March-May	March – April
	(c) Mode of pollination	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily	Entomophilous, Anemophilous and Malacophily
	4 (a) fruit formation	September-October	September-October	September-October	October	September-October	September-October	September-October	September-October
	(b) Fruit maturation	November	November	November	November	November	November	November	November
Post Reproductive Phase	**5** Dispersal of seed	December	December	November	Nowember	December	November	December	December
	6 Dormency of plant	November-December	November-December	November-December	November-December	November-December	November-December	November-December	November-December

Table 3.4: Phenological features of *Crinum latifolium* L.

Phases		CLAS	CLBA	CLGA	CLKA	CLKO	CLNA	CLOD	CLPA	CLPU	CLSH
Vegetative phases	1 Bulb sprout	February-March	February-March	February-March	July	February	February	February	February	February	February
	2 Active vegetative	May-October	May-October	May-October	May-October	May-October	May-October	May-October	May-October	May-October	May-October
Reproductive phase	3(a) Emergence of inflorescence	January-February	February-March	February-March	June - July	January-February	January-February	January-February	January-February	February-March	January-February
	(b) Inflorescence of full bloom	March - April	March - May	March - April	August - September	March - April	March - April	March - May	March - April	April-June	March
	(c) Mode of pollination	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous	Entomophilous and Anemophilous
	4 (a) fruit formation	Not found	Not found	April	October	Not found	Not found	Not found	May	September	Not found
	(b) Fruit maturation	Not found	Not found	May	November	Not found	Not found	Not found	June	October	Not found
Post Reproductive Phase	5 Dispersal of seed	Not found	Not found	May	Nowember	Not found	Not found	Not found	End of June	October	Not found
	6 Dormency of plant	November-December	November-December	November-December	November-December	November-December	November-December	November-December	November-December	November-December	November-December

Table 3.5: Phenological clock shows appearance of different features of both the species round the year.

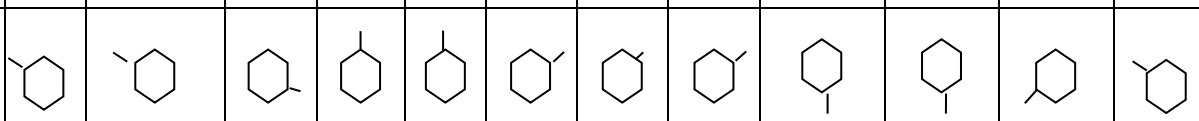
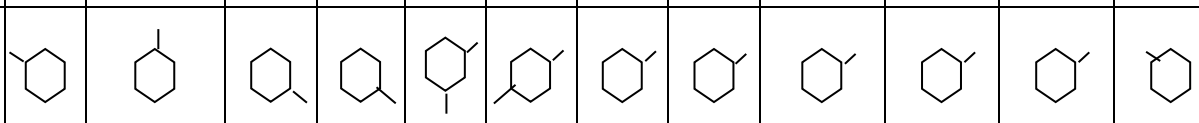
Name of species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
C. asiaticum												
C. latifolium												

Table 3.6: Morphological features of *Crinum asiaticum* L.

Parameter	CAKO	CAMO	CANA	CANO	CAPA	CAPU	CASH	CASU
Habit	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb
Habitat	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial
PL. height (cm)	134.56 ±9.75	22.28 ±2.86	121.70 ±11.49	162.56 ±11.94	197 ±12.97	25.56 ±4.20	28.24 ±3.81	26.56 ±3.99
Plant growth diameter (cm)	250.68 ±07.69	70.88 ±02.83	247.90 ±10.17	264.30 ±15.70	193.60 ±09.70	37.72 ±01.83	112.40 ±06.33	107.00 ±07.15
Phyllotaxy	Spiral	Spiral	Spiral	Spiral	Spiral	Alternate	Spiral	Spiral
Shape of bulb	Ovate	Globose	Ovate	Ovate	Ovate	Ovate	Globose	Ovate
Neck of bulb	Large rounded neck	Neck absent	Large rounded neck	Large rounded neck	Large rounded neck	Narrow round neck	Neck absent	Narrow round neck
Bulb length (cm)	18.11 ±00.65	06.86 ±00.33	18.11 ±00.65	23.30 ±01.70	18.11 ±00.65	05.00 ±00.11	07.94 ±00.26	11.85 ±00.53
Bulb diameter (cm)	02.90 ±00.18	02.90 ±00.18	02.94 ±00.16	04.60 ±00.20	05.10 ±00.24	02.94 ±00.16	02.50 ±00.54	02.50 ±00.54
Leaf length (cm)	126.70 ±10.78	35.75 ±04.77	124.76 ±09.38	136.48 ±09.74	95.28 ±05.50	19.00 ±00.44	52.70 ±03.87	52.10 ±03.15
Leaf width (cm)	10.00 ±00.15	03.20 ±00.25	11.57 ±00.95	12.00 ±00.45	11.31 ±00.87	01.20 ±00.03	03.10 ±00.08	02.00 ±00.16
Leaf	Entire	Entire	Entire	Entire	Entire	Entire	Entire	Entire

margin								
Inflorescence	Umbel	Umbel	Umbel	Umbel	Umbel	Umbel	Umbel	Umbel
Scape height (cm)	43.92 ±01.86	26.00 ±03.22	55.16 ±05.24	56.96 ±04.90	55.00 ±05.24	23.00 ±02.21	32.40 ±03.91	34.68 ±03.85
Scape colour	Greenish	Greenish	Greenish	Greenish	Greenish	Greenish	Greenish	Greenish
Scape diameter (cm)	02.00 ±00.12	01.80 ±00.26	02.10 ±00.24	02.50 ±00.07	02.18 ±00.24	01.00 ±00.03	01.49 ±00.05	01.90 ±00.22
Number of flower per scape	22.80 ±00.86	11.96 ±01.39	19.84 ±02.39	31.00 ±01.52	21.64 ±01.60	06.00 ±00.13	09.00 ±00.15	22.00 ±00.91
No. of bract	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59	02.24 ±00.59
Length of bract (cm)	07.99 ±00.25	04.90 ±00.22	08.40 ±00.50	08.85 ±00.45	08.40 ±00.50	04.50 ±00.94	05.39 ±00.28	08.00 ±00.13
No. of bracteole	15.00 ±00.73	02.24 ±00.59	02.24 ±00.59	12.00 ±00.24	02.24 ±00.59	02.24 ±00.59	03.10 ±00.24	02.00 ±00.08
Length of bracteole (cm)	06.97 ±00.20	04.40 ±00.22	07.90 ±00.57	08.10 ±00.11	07.97 ±00.57	07.90 ±00.57	05.21 ±00.28	07.45 ±00.20
Flower colour	White	White	White	White	White	White	White	White
Perianth type	Salver-shaped	Salver-shaped	Salver-shaped	Salver-shaped	Salver-shaped	Salver-shaped	Salver-shaped	Salver-shaped
Shape of perianth	Tube-linear	Tube-linear	Tube-linear	Tube-linear	Tube-linear	Tube-oblong	Tube-linear	Tube-linear
Length of petiole (cm)	01.00 ±00.07	01.02 ±00.09	01.00 ±00.07	01.00 ±00.07	01.01 ±00.07	01.00 ±00.07	01.00 ±00.07	01.00 ±00.07
Width of petiole (cm)	00.76 ±00.10	00.95 ±00.20	00.76 ±00.10	00.70 ±00.09	00.76 ±00.10	00.76 ±00.10	00.76 ±00.10	00.76 ±00.06
Length of tepal (cm)	11.53 ±00.59	11.53 ±00.59	11.53 ±00.59	11.53 ±00.59	12.54 ±00.87	11.53 ±00.59	09.20 ±00.55	08.72 ±00.79
Venation of tepal	09.36 ±05.33	07.70 ±00.59	07.84 ±00.55	08.16 ±00.62	07.84 ±00.55	07.80 ±00.55	07.80 ±00.55	07.72 ±00.61
Aestivation	Imbricate	Imbricate	Imbricate	Imbricate	Imbricate	Imbricate	Imbricate	Imbricate
Androecium	Epiphyllous	Epiphyllous	Epiphyllous	Epiphyllous	Epiphyllous	Epiphyllous	Epiphyllous	Epiphyllous
No. of stamen	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00	06.00 ±00.00
Colour of stamen	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Type of anther	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular
Length of anther (cm)	05.99 ±00.20	05.90 ±00.20	05.87 ±00.30	05.45 ±00.43	05.90 ±00.28	05.80 ±00.30	06.00 ±00.20	05.20 ±00.39
Length of filament (cm)	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23	01.90 ±00.23

Attachment of anther	Dorsifixed	Dorsifixed	Dorsifixed	Dorsifixed	Dorsifixed	Dorsifixed	Dorsifixed	Dorsifixed
Gynoecium	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous
Length of style (cm)	10.68 ±00.40	16.90 ±00.43	14.94 ±00.29	10.68 ±00.40	18.14 ±00.49	14.94 ±00.29	17.80 ±00.34	16.99 ±01.38
Length of stigma (cm)	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04	00.28 ±00.04
Placentation	Axile	Axile	Axile	Axile	Axile	Axile	Axile	Axile
Type of ovary	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior
Length of ovary (cm)	01.93 ±00.23	01.13 ±00.13	01.40 ±00.13	01.20 ±00.15	02.00 ±00.14	01.40 ±00.13	01.40 ±00.13	01.29 ±00.25
Width of ovary (cm)	01.40 ±00.08	01.40 ±00.08	01.40 ±00.08	01.40 ±00.08	01.40 ±00.08	01.40 ±00.08	01.50 ±00.03	01.50 ±00.03
Fruit	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule
Seed	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy	Endosperm fleashy
Seed colour	Grey	Grey	Grey	Grey	Grey	Grey	Whitish	Grey
Seed Shape	Uneven rounded	Uneven rounded	Uneven rounded	Uneven rounded	Uneven rounded	Uneven rounded	Uneven rounded	Uneven rounded

Table 3.7: Leaf anatomical features of different provenance of *Crinum asiaticum* L.

Parameter	CAKO	CAMO	CANA	CANO	CAPA	CAPU	CASH	CASU
Stomata	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic
Vascular bundle type	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral
Vascular bundle Shape	Round	Ovoid	Ovoid	Elliptical	Ovoid	Ovoid	Ovoid	Ovoid
No. of vascular bundle	17.92 **±00.49**	17.92 **±00.49**	17.92 **±00.49**	23.76 **±01.00**	17.92 **±00.49**	19.68 **±01.10**	19.68 **±01.10**	18.48 **±00.87**
No. upper epidermal cells	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**	01.00 **±00.00**
Shape of upper epidermal layer	Uneven	Even	Even	Even	Even	Even	Even	Uneven

Table 3.8: Root anatomical features of different provenance of *Crinum asiaticum* L.

Parameter	CAKO	CAMO	CANA	CANO	CAPA	CAPU	CASH	CASU
Type of vascular bundle	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch
No. of epidermis cells	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	03.84 ±00.55	02.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00
Cortex region (µm)	159.76 ±05.25	181.00 ±03.09	170.00 ±01.20	73.84 ±02.00	94.96 ±00.93	22.00 ±01.60	43.12 ±01.50	95.56 ±01.29
No. of pericycle layer	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00
No. of xylem strand	12.00 ±00.00	12.00 ±00.00	16.00 ±00.00	22.00 ±00.00	12.88 ±00.33	07.90 ±00.27	08.88 ±00.33	08.00 ±00.27
Size of pith cells	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform
Diameter of stele (µm)	74.12 ±02.36	68.48 ±03.41	79.80 ±01.00	45.92 ±02.46	60.00 ±02.80	11.92 ±01.40	32.76 ±01.66	64.40 ±02.25

Table 3.9: Morphological features of *Crinum latifolium* L.

Parameter	**CLAS**	**CLBA**	**CLGA**	**CLKA**	**CLKO**	**CLNA**	**CLOD**	**CLPA**	**CLPU**	**CLSH**
Habit	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb	Leafy herb
Habitat	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Terrestrial
PL. height (cm)	54.60 **±11.20**	54.60 **±11.20**	55.10 **±11.20**	56.56 **±09.51**	41.68 **±08.20**	32.70 **±03.26**	50.76 **±03.96**	84.40 **±08.75**	93.80 **±05.90**	30.96 **±02.70**
Plant growth diameter(cm)	62.80 **±07.90**	108.80 **±33.64**	102.60 **±26.50**	100.60 **±14.20**	86.96 **±04.96**	58.00 **±04.27**	68.88 **±06.28**	168.88 **±06.28**	181.56 **±11.07**	63.36 **±02.37**
Phyllotaxy	Opposite	Spiral	Opposite	Spiral	Spiral	Spiral	Spiral	Spiral	Spiral	Spiral
Shape of bulb	ovate	elliptic	Spherical	Spherical	Widely elliptic	Broad ovate	ovate	Spherical	Spherical	Ovate
Neck of bulb	Large flattened neck	Narrow round neck	Neck absent	Highly enlarge round neck	Neck absent	Narrow flattened neck	Narrow round neck	Neck absent	Neck absent	Neck absent
Bulb length (cm)	04.90 **±00.20**	02.30 **±00.24**	07.00 **±00.29**	04.96 **±00.20**	04.30 **±00.48**	02.10 **±00.21**	04.37 **±00.48**	06.00 **±00.11**	03.00 **±00.12**	02.60 **±00.03**
Bulb diameter (cm)	08.80 **±00.30**	07.10 **±00.32**	24.00 **±00.80**	15.98 **±00.18**	12.95 **±00.29**	06.10 **±00.33**	07.11 **±00.32**	18.97 **±00.21**	13.97 **±00.47**	07.11 **±00.32**
Leaf length (cm)	32.10 **±04.70**	57.00 **±00.85**	56.80 **±03.51**	52.40 **±01.73**	45.00 **±05.40**	28.28 **±02.30**	34.80 **±04.49**	84.56 **±08.79**	87.24 **±03.80**	32.00 **±04.26**
Leaf width (cm)	01.90 **±00.10**	01.90 **±00.16**	05.00 **±00.24**	02.00 **±00.17**	02.50 **±00.20**	02.70 **±00.25**	01.99 **±00.16**	02.10 **±00.15**	02.10 **±00.13**	01.60 **±00.03**
Leaf margin	Plane	Plane	Plane	Plane	Plane	Plane	Plane	Plane	Plane	Plane
Inflorescence	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme	Umbellate cyme
Scape height (cm)	33.80 **±04.20**	57.70 **±03.50**	31.90 **±03.20**	52.80 **±01.97**	64.20 **±02.36**	54.32 **±03.32**	41.80 **±02.25**	37.04 **±04.48**	80.68 **±08.51**	34.76 **±04.78**
Scape colour	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Scape diameter (cm)	01.40 **±00.20**	01.10 **±00.08**	01.49 **±00.03**	01.30 **±00.12**	01.35 **±00.07**	01.10 **±00.08**	01.13 **±00.08**	01.10 **±00.08**	01.39 **±00.06**	01.10 **±00.08**
Number of flower per scape	02.10 **±00.50**	04.60 **±00.47**	02.10 **±00.47**	05.36 **±00.95**	04.70 **±00.97**	04.40 **±00.65**	04.40 **±00.76**	04.40 **±00.76**	04.40 **±00.76**	02.24 **±00.59**
No. of bract	02.20 **±00.50**	02.20 **±00.59**	02.10 **±00.47**	02.24 **±00.59**	02.24 **±00.59**	02.20 **±00.59**	02.24 **±00.59**	02.24 **±00.59**	02.24 **±00.59**	02.24 **±00.59**
Length of bract (cm)	05.10 **±00.10**	06.20 **±00.19**	09.11 **±00.23**	05.27 **±00.32**	06.00 **±00.09**	08.10 **±00.10**	06.20 **±00.17**	05.56 **±00.13**	05.7 **±00.14**	04.49 **±00.09**
No. of bracteole	03.50 **±00.80**	07.00 **±00.20**	02.16 **±00.47**	02.50 **±00.91**	02.50 **±00.91**	02.56 **±00.91**	02.24 **±00.59**	02.24 **±00.59**	03.10 **±01.01**	02.24 **±00.59**

Length of bracteole (cm)		03.00 **±00.20**	02.70 **±00.33**	04.60 **±00.30**	03.10 **±00.24**	03.10 **±00.24**	03.10 **±00.24**	04.18 **±00.08**	03.55 **±00.11**	02.50 **±00.03**	02.00 **±00.06**
Flower colour		Red tinted white	Pink tinted green	Red tinted yellow	White with pink stripe	Pink tinted yellow	Red tinted white and light green	Red tinted yellow	Red tinted white	Pink tinted green	Pink tinted green
Perianth type		Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped	Funnel shaped
Shape of perianth		Lance-ovate	Lanceo late	Ovate	Lanceo late	Lanceo late	Ovate	Obovat e	Lance-ovate	Elliptic	Linear lanceol ate
Length of petiole (cm)		05.70 **±00.20**	07.00 **±00.42**	08.19 **±00.08**	06.64 **±00.26**	07.10 **±00.33**	06.30 **±00.11**	06.20 **±00.32**	06.23 **±00.32**	06.24 **±00.22**	04.49 **±00.09**
Width of petiole (cm)		00.50 **±00.07**	00.67 **±00.06**	00.88 **±00.03**	00.66 **±00.05**	00.5 **±00.02**	00.67 **±00.06**	00.63 **±00.03**	00.67 **±00.06**	00.60 **±00.04**	00.40 **±00.01**
Length of tepal (cm)		08.90 **±00.20**	12.90 **±00.19**	12.64 **±00.46**	11.23 **±00.37**	10.78 **±00.40**	11.10 **±00.08**	11.00 **±00.40**	11.68 **±00.35**	11.20 **±00.22**	09.60 **±00.04**
Venation of tepal		18.00 **±00.30** 20.00 **±00.40** 22.60 **±00.70** 20.60 **±01.10** 18.00 **±00.70** 20.70 **±00.90**	25.30 **±00.74** 20.20 **±00.60** 24.80 **±00.83** 22.60 **±02.40** 18.10 **±00.78** 20.60 **±00.98**	28.00 **±01.44** 24.90 **±00.81** 20.31 **±00.61** 23.50 **±01.66** 18.16 **±00.74** 20.56 **±00.96**	25.70 **±00.79** 20.76 **±01.09** 22.64 **±00.81** 21.24 **±01.23** 14.00 **±00.70** 25.70 **±00.79**	26.00 ±00.73 21.24 **±01.23** 23.10 **±00.94** 20.76 **±01.00** 18.10 **±00.78** 17.90 **±00.81**	17.92 **±00.81** 21.24 **±01.23** 18.00 **±00.70** 23.28 **±02.13** 17.88 **±00.78** 23.76 **±02.00**	21.24 **±01.24** 20.26 **±00.60** 18.12 **±00.78** 17.92 **±00.81** 22.60 **±02.48** 20.80 **±00.91**	17.92 **±00.81** 15.84 **±00.62** 18.01 **±00.78** 21.24 **±01.23** 26.60 **±00.76** 23.28 **±02.13**	17.96 **±00.78** 21.24 **±01.23** 19.24 **±01.16** 26.6 **±00.76** 21.20 **±01.19** 23.28 **±02.13**	17.92 **±00.81** 15.84 **±00.62** 18.12 **±00.78** 21.24 **±01.23** 26.60 **±00.76** 23.28 **±02.13**
Aestivation		Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial	Quincuntial
Androeciu m		Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous	Epiphy llous
No. of stamen		06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**	06.00 **±00.00**
Colour of stamen		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Type of anther		Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular	Bilocular
Length of anther (cm)		00.39 **±00.01**	00.42 **±00.05**	00.58 **±00.02**	00.49 **±00.04**	00.42 **±00.04**	00.42 **±00.04**	00.42 **±00.05**	00.59 **±00.09**	00.52 **±00.03**	00.40 **±00.12**
Length of filament (cm)	1	07.60 **±00.19**	08.30 **±00.11**	09.27 **±00.11**	07.60 **±00.19**	08.70 **±00.09**	07.70 **±00.07**	08.40 **±00.51**	08.40 **±00.13**	09.50 **±00.02**	08.50 **±00.05**
	2	06.60 **±00.14**	08.60 **±00.09**	08.62 **±00.18**	06.60 ±00.14	08.30 **±00.11**	07.40 **±00.17**	08.50 **±00.09**	08.50 **±00.05**	09.89 **±00.08**	08.40 **±00.13**
	3	07.30 **±00.11**	07.40 **±00.25**	08.40 **±00.09**	07.30 **±00.11**	09.00 **±00.08**	07.40 **±00.23**	08.16 **±00.13**	08.20 **±00.09**	07.90 **±00.03**	08.87 **±0.06**

	4	06.60 **±00.16**	07.80 **±00.02**	08.60 **±00.18**	06.60 **±00.14**	08.69 **±00.09**	07.89 **±00.02**	07.89 **±00.24**	07.40 **±00.11**	07.90 **±00.03**	09.10 **±00.06**
	5	07.60 **±00.09**	08.80 **±00.06**	09.27 **±00.11**	07.60 **±00.09**	08.70 **±00.03**	07.30 **±00.17**	07.50 **±00.10**	07.90 **±00.03**	08.50 **±00.05**	08.69 **±00.09**
	6	07.50 **±00.10**	07.50 **±00.10**	09.27 **±00.11**	07.50 **±00.10**	08.30 **±00.11**	07.30 **±00.15**	07.00 **±00.09**	07.90 **±00.03**	08.50 **±00.05**	08.27 **±00.09**
Attachment of anther		50% **±00.90**	50% **±00.90**	60% **±01.55**	60% **±00.98**	50% **±01.28**	50% **±00.90**	60% **±01.38**	50% **±00.90**	60% **±01.35**	50% **±00.90**
Gynoecium		Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous	Syncarpous
Length of style (cm)		11.86 **±00.33**	09.40 **±00.13**	12.85 **±00.36**	11.80 **±00.31**	10.08 **±01.80**	11.79 **±00.08**	11.96 **±00.27**	11.70 **±00.34**	11.32 **±00.21**	11.47 **±00.26**
Length of stigma (cm)		00.30 **±00.01**	00.30 **±00.20**	00.49 **±00.01**	00.30 **±00.01**	00.30 **±00.01**	00.47 **±00.06**	00.39 **±00.02**	00.30 **±00.03**	00.49 **±00.08**	00.20 **±00.02**
Placentation		Axile	Axile	Axile	Axile	Axile	Axile	Axile	Axile	Axile	Axile
Type of ovary		Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior	Inferior
Length of ovary (cm)		01.20 ±00.10	00.80 **±00.07**	01.39 **±00.01**	00.79 **±00.01**	01.40 **±00.08**	00.89 **±00.07**	01.29 **±00.04**	01.50 **±00.02**	01.00 **±00.04**	00.70 **±00.02**
Width of ovary (cm)		00.67 **±00.01**	00.55 **±00.01**	00.56 **±00.02**	00.60 **±00.01**	00.58 **±00.03**	00.57 **±00.01**	00.60 **±00.13**	00.60 **±00.01**	00.60 **±00.01**	00.55 ±00.03
Fruit		Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule	Capsule
Seed		Albuminous	Albuminous	Albuminous	Albuminous	Albuminous	Albuminous	Albuminous	Albuminous	Albuminous	Albuminous
Seed colour		Black	Black	Black	Black	Black	Black	Black	Black	Black	Black
Seed Shape		Uneven	Uneven	Uneven	Uneven	Uneven	Uneven	Uneven	Uneven	Uneven	Uneven

Table 3.10: Leaf anatomical features of different provenance of *Crinum latifolium* L.

Parameter	CLAS	CLBA	CLGA	CLKA	CLKO	CLNA	CLOD	CLPA	CLPU	CLSH
Stomata	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic	Diacytic
Type of vascular bundle	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral	Closed collateral
Shape of vascular bundle	Ovoid	Ovoid	Flask uneven	Elliptical	Round	Ovoid	Ovoid	Elliptical	Ovoid	Ovoid
No. of vascular bundle	16.36 ±00.81	25.32 ±01.18	22.00 ±00.81	27.96 ±00.84	16.36 ±00.81	17.00 ±01.00	16.36 ±00.81	35.48 ±01.32	32.48 ±01.66	37.76 ±01.2
No. upper epidermal cells	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00
Shape of upper epidermal layer	Even	Even	Even	uneven	uneven	Even	Even	Even	uneven	Even

Table 3.11: Root anatomical features of different provenance of *Crinum latifolium* L.

Parameter	CLAS	CLBA	CLGA	CLKA	CLKO	CLNA	CLOD	CLPA	CLPU	CLSH
Type of vascular bundle	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch	Radial polyarch
No. of epidermis cells	02.00 ±00.00	01.00 ±00.00	01.00 ±00.00	02.00 ±00.00	02.00 ±00.00	02.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	02.00 ±00.00
Cortex region (µm)	39.56 ±02.88	79.67 ±02.28	79.64 ±02.29	50.16 ±02.11	41.40 ±01.41	59.44 ±01.93	118.52 ±05.37	59.44 ±01.93	39.32 ±03.18	79.64 ±02.28
No. of pericycle layer	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00	01.00 ±00.00
No. of xylem strand	06.00 ±00.00	05.00 ±00.00	06.00 ±00.00	06.00 ±00.00	08.00 ±00.00	07.00 ±00.00	10.00 ±00.00	08.00 ±00.00	06.00 ±00.00	08.00 ±00.00
Size of pith cells	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform
Diameter of stele (µm)	10.85 ±01.24	11.33 ±01.06	29.59 ±01.89	29.59 ±01.89	22.80 ±01.00	21.00 ±01.32	48.92 ±02.51	27.92 ±01.73	20.24 ±01.42	35.32 ±02.19

Table 3.12: Different features and their state used in numerical taxonomy

Parameter	Numerical no
Habit	Leafy herb=0
Habitat	Terrestrial=0
PL. height (cm)	20-25=0, 26-42=1, 43-55=2, 56-70=3, 71-90=4, 91-120=5, 121-140=6, 141-200=7
Plant growth diameter(cm)	30-60=0, 61-80=1, 81-100=2, 101-120=3, 121-180=4, 181-200=5, 201-250=6, 251-270=7
Phyllotaxy	Spiral=0, Alternate=1, Opposite=2
Shape of bulb	Ovate=0, elliptic=1, Spherical=2, Widely elliptic=3, Broad ovate=4, Globose=5
Neck of bulb	Neck absent=0, Large rounded neck=1, Narrow round neck=2, Narrow flattened neck=3, Highly enlarge round neck=4
Bulb length (cm)	1-2.5=0, 2.6-4.5=1, 4.6-7.5=2, 7.6-15.5=3, 15.6-18.5=4, 18.6-25.5=5
Bulb diameter (cm)	2-3.99=0, 4-5.99=1, 6-7.99=2
Leaf length (cm)	19-31=0, 32-44=1, 45-57=2, 58-89=3, 90-130=4, 131-150=5
Leaf width (cm)	1-1.99=0, 2-2.99=1, 3-3.99=2, 4-5=3, 6-10=4, 11-12=5
Leaf margin	Plane=0, Entire=1
Inflorescence	Umbel=0, Umbellate cyme=1
Scape height (cm)	20-30=0, 31-40=1, 41-50=2, 51-60=3, 61-70=4, 71-90=5
Scape colour	Green=0, Greenish=1
Scape diameter (cm)	1-1.99=0, 2-2.99=1
Number of flower per scape	2-4=0, 4.1-6=1, 7-9=2, 10-20=3, 21-23=4
No. of bract	2-2.1=0, 2.2-2.3=1
Length of bract (cm)	4-5.99=0, 6-7.99=1, 8-9.99=2
No. of bracteole	2-3.99=0, 4-7=1, 8-15=2
Length of bracteole (cm)	2-3.99=0, 4-5.99=1, 6-7.99=2, 8-9=3
Flower colour	Pink tinted yellow=0, Pink tinted green=1, Red tinted white=2, Red tinted yellow=3, White with pink stripe=4, Red tinted white and light green=5, White=6
Perianth type	Funnel shaped=0, Salver- shaped=1

Shape of perianth	Ovate=0, Lance-ovate=1, Lanceolate =2, Obovate =3, Elliptic=4, Linear lanceolate =5, Tube-linear=6, Tube-oblong=7
Length of petiole (cm)	0-2=0, 3-5=1, 6-9=2,
Width of petiole (cm)	0-0.5=0, 0.51-1=1
Length of tepal (cm)	8-9.99=0, 10-11.99=1, 12-13.99=2
Venation of tepal	7-8.99=0, 9-10.99=1, 11-12.99=2, 13-18.99=3, 19-25.99=4, 26-28=5
Aestivation	Quincuntial=0, Imbricate=1
Androecium	Epiphyllous=0
No. of stamen	6=0
Colour of stamen	Yellow=0
Type of anther	Bilocular=0
Length of anther (cm)	0-0.5=0, 0.51-1=1, 2-6=2
Length of filament (cm)	0-1.99=0, 2-6.99=1, 7-8.99=2, 9-10=3
Attachment of anther	Dorsifix=0
Gynoecium	Syncarpous=0
Length of style (cm)	9-11.99=0, 12-13.99=1, 14-18.99=2
Length of stigma (cm)	0-0.29=0, 0.30-0.49=1
Placentation	Axile=0
Type of ovary	Inferior=0
Length of ovary (cm)	0-0.99=0, 1-1.99=1, 2-3=2
Width of ovary (cm)	0-0.5=0, 0.51-0.99=1, 1-1.5=2
Fruit	Capsule=0
Seed	Albuminous=0, Endosperm fleashy=1
Seed colour	Black=0, Grey=1, Whitish=2
Seed Shape	Uneven=0, Uneven rounded=1
stomata	Diacytic=0
Type of vascular bundle	Closed collateral=0
Shape of vascular bundle	Ovoid=0, Flask uneven=1, Elliptical=2, Round=3

No. of vascular bundle	16-17.99=0, 18-19.99=1, 20-21.99=2, 22-23.99=3, 24-27.99=4, 28-30.99=5,31-37.99=6
No. upper epidermal cells	1=0
Shape of upper epidermal layer	Even=0, uneven=1
Type of vascular bundle	Radial polyarch=0
No. of epidermis cells	1-2=0, 3-4=1
Cortex region (µm)	22-39.99=0, 40-49.99=1, 50-59.99=2, 60-79.99=3, 80-99.99=4, 100-119.99=5, 120-182=6
No. of pericycle layer	1=0
No. of xylem strand	5-6.99=0, 7-8.99=1, 9-10.99=2, 11-16=3
Size of pith cells	Uniform=1

Figure 3.2: Morphological outlook of *C. asiaticum*. (CAPU, CAPA, CAKO, CANA, CASH, CANO, CASU- From left side).

Figure 3.3: Morphological outlook of *C. latifolium*. (CLAS, CLKO, CLPA, CLPU, CLNA, CLOD, CLBA, CLSH, CLKA & CLGA respectively from left side).

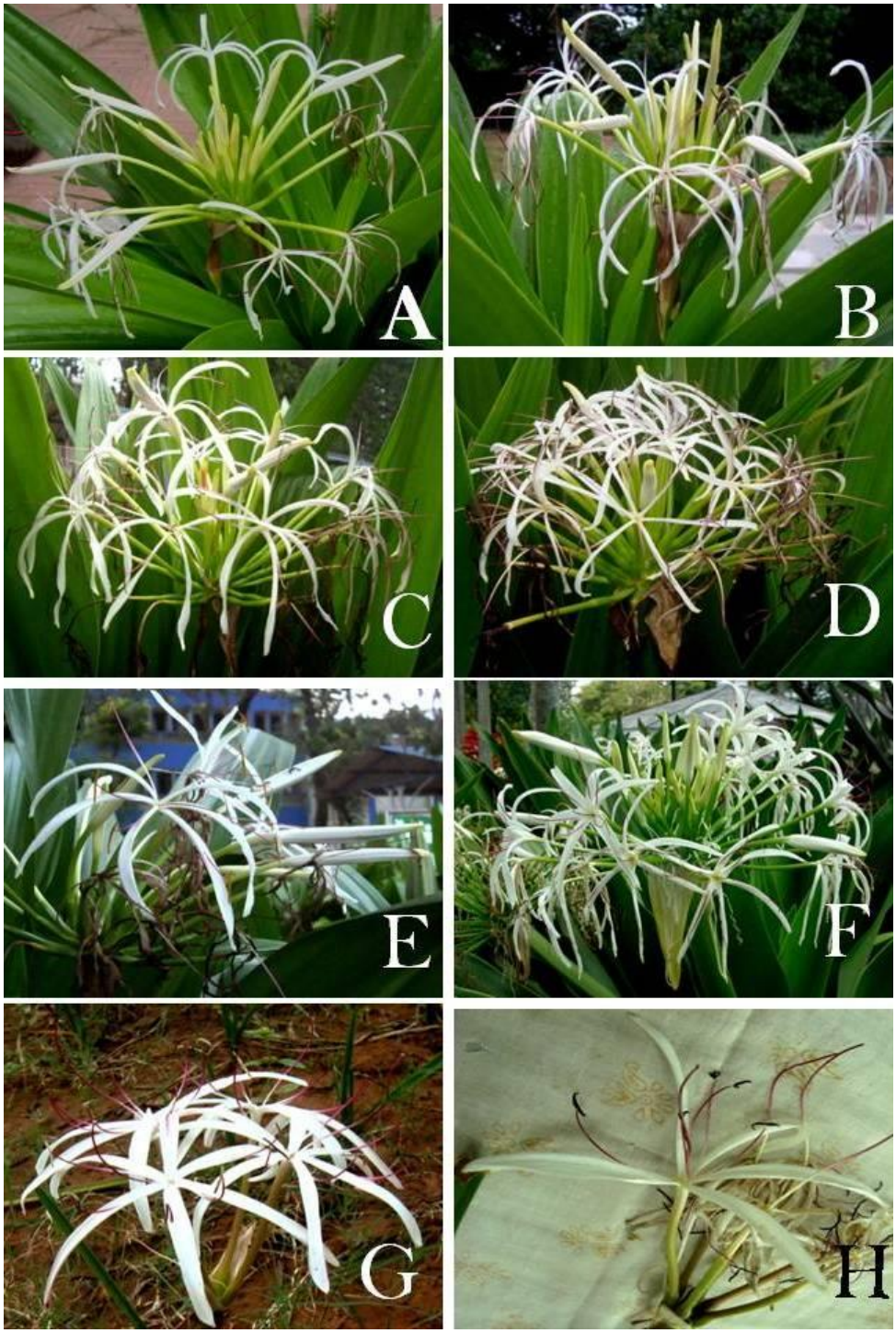


Figure 3.4: Flowers of *Crinum asiaticum* L. of different locations.A) CAKO, B) CAMO, C) CANA, D) CANO, E) CAPA, F) CAPU, G) CASH & H) CASU.

Figure 3.5: Flowers of *Crinum latifolium* L. of different locations. A) CLAS, B) CLBA, C) CLGA, D) CLKA, E) CLKO, F) CLNA, G) CLOD, H) CLPA, I) CLPU & J) CLSH.

Figure 3.6: Leaf of *C. latifolium* L. of different location. A) CLPU, B) CLPA, C) CLBA, D) CLGA, E) CLKA, F) CLKO, G) CLOD, H) CLAS, I) CLSH & J) CLNA (Leaves are arrange according to their size).

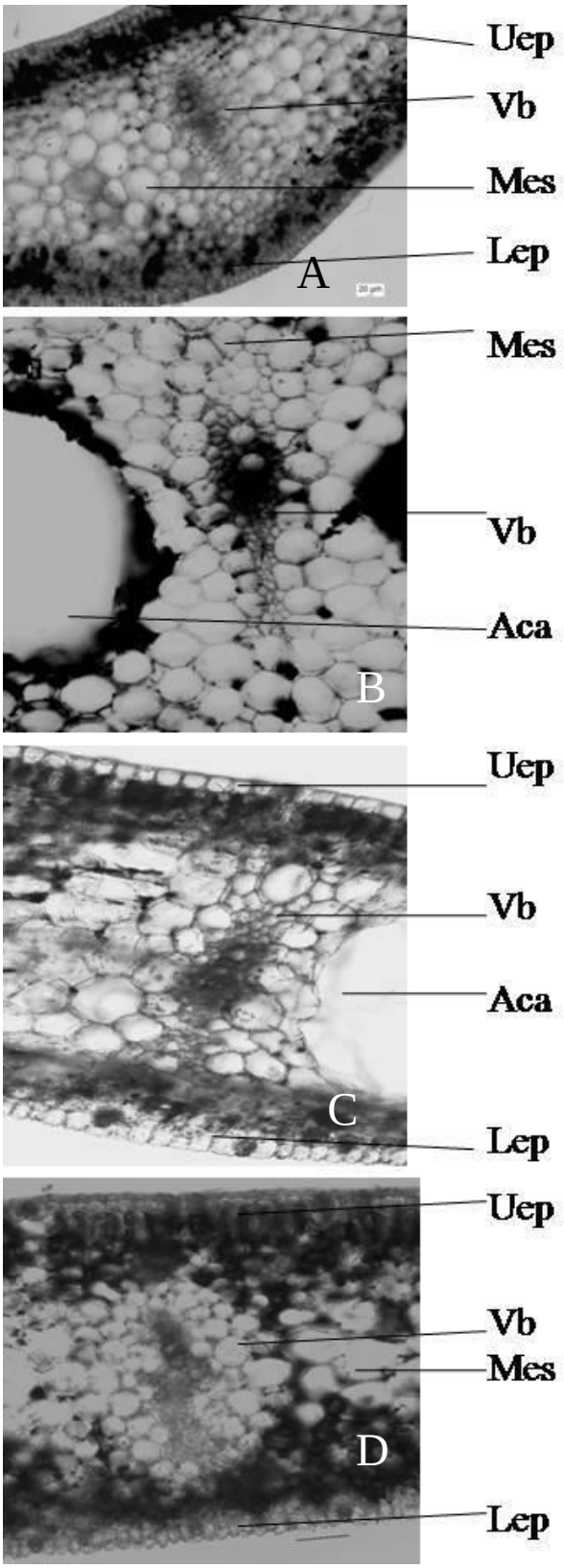


Figure 3.7: Transverse section of leaf of *C. asiaticum* L. A) CAKO, B) CAMO, C) CANA & D) CANO (Aca – Air cavity, Uep – Upper epidermis, Lep – Lower epidermis, Vb- Vascular bundle, Mes – Mesophyll tissue. Bar is 20 µm).

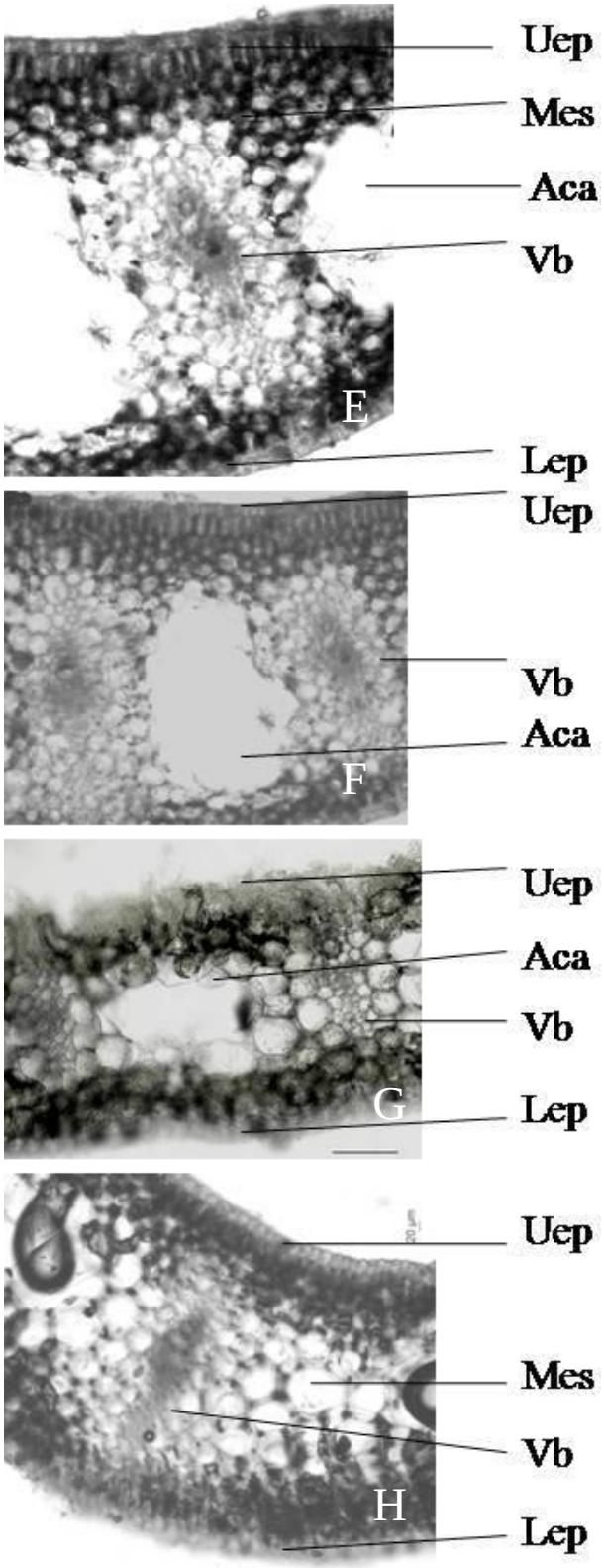


Figure 3.8: Transverse section of leaf of *C. asiaticum* L. E) CAPA, F) CAPU, G) CASH & H) CASU. (Aca – Air cavity, Uep – Upper epidermis, Lep – Lower epidermis, Vb- Vascular bundle, Mes – Mesophyll tissue. Bar is 20 µm).

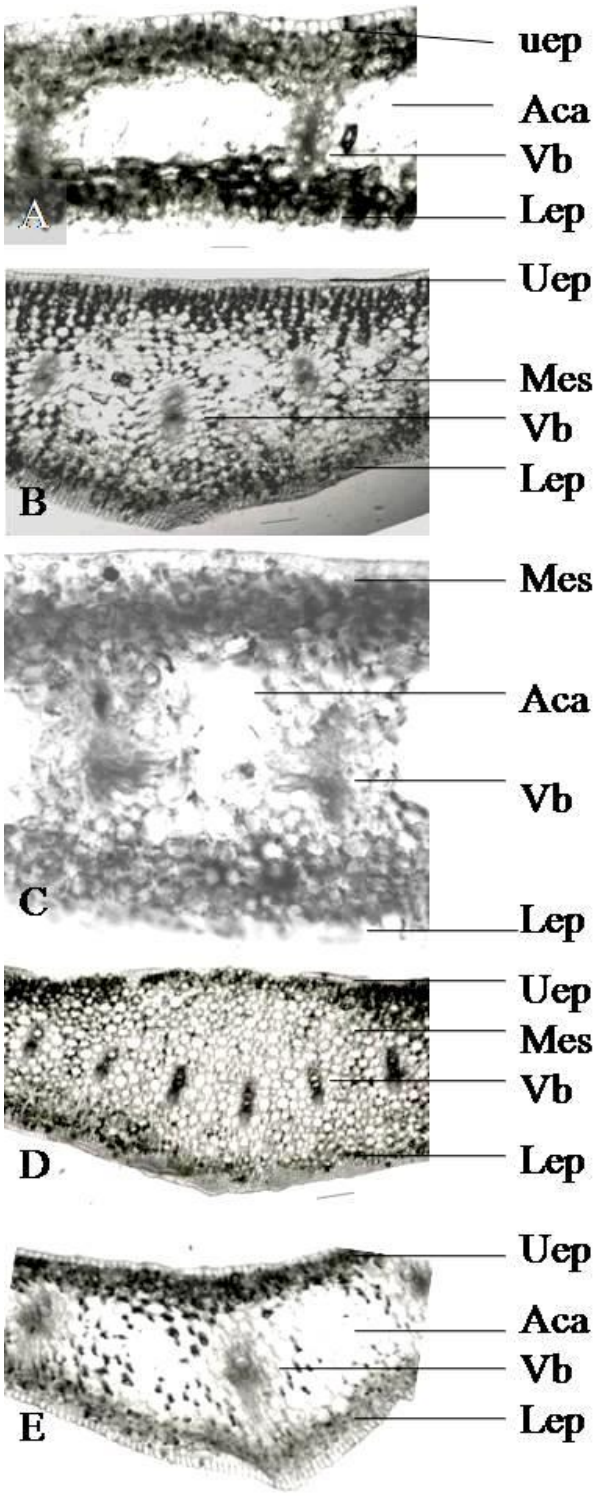


Figure 3.9: Transverse section of leaf of *C. latifolium* L. A) CLAS, B) CLBA, C) CLGA, D) CLKA & E) CLKO (Aca – Air cavity, Uep – Upper epidermis, Lep – Lower epidermis, Vb- Vascular bundle, Mes – Mesophyll tissue. Bar is 20 µm).

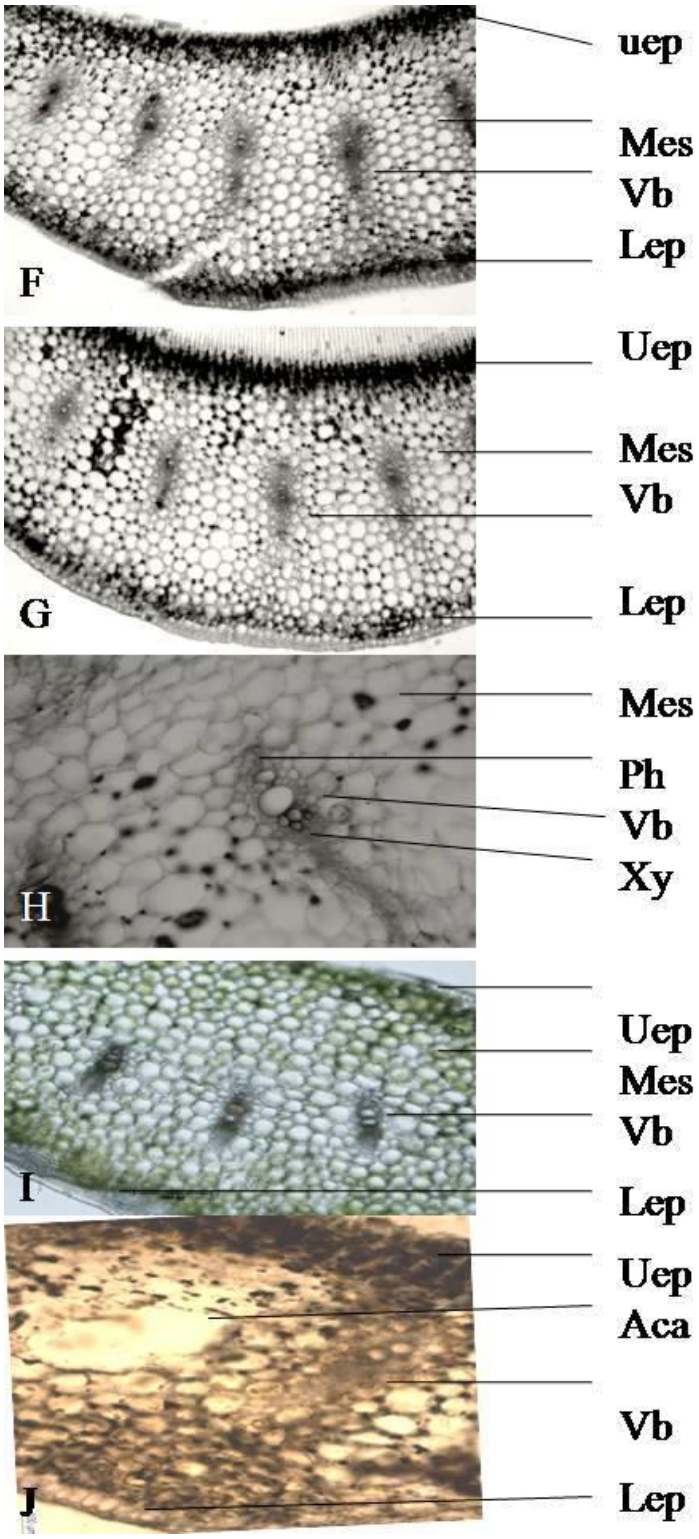


Figure 3.10: Transverse section of leaf of *C. latifolium* L. F) CLNA, G) CLOD, H) CLPA, I) CLPU & J) CLSH (Aca – Air cavity, Uep – Upper epidermis, Lep – Lower epidermis, Vb- Vascular bundle, Mes – Mesophyll tissue. Bar is 20 µm).

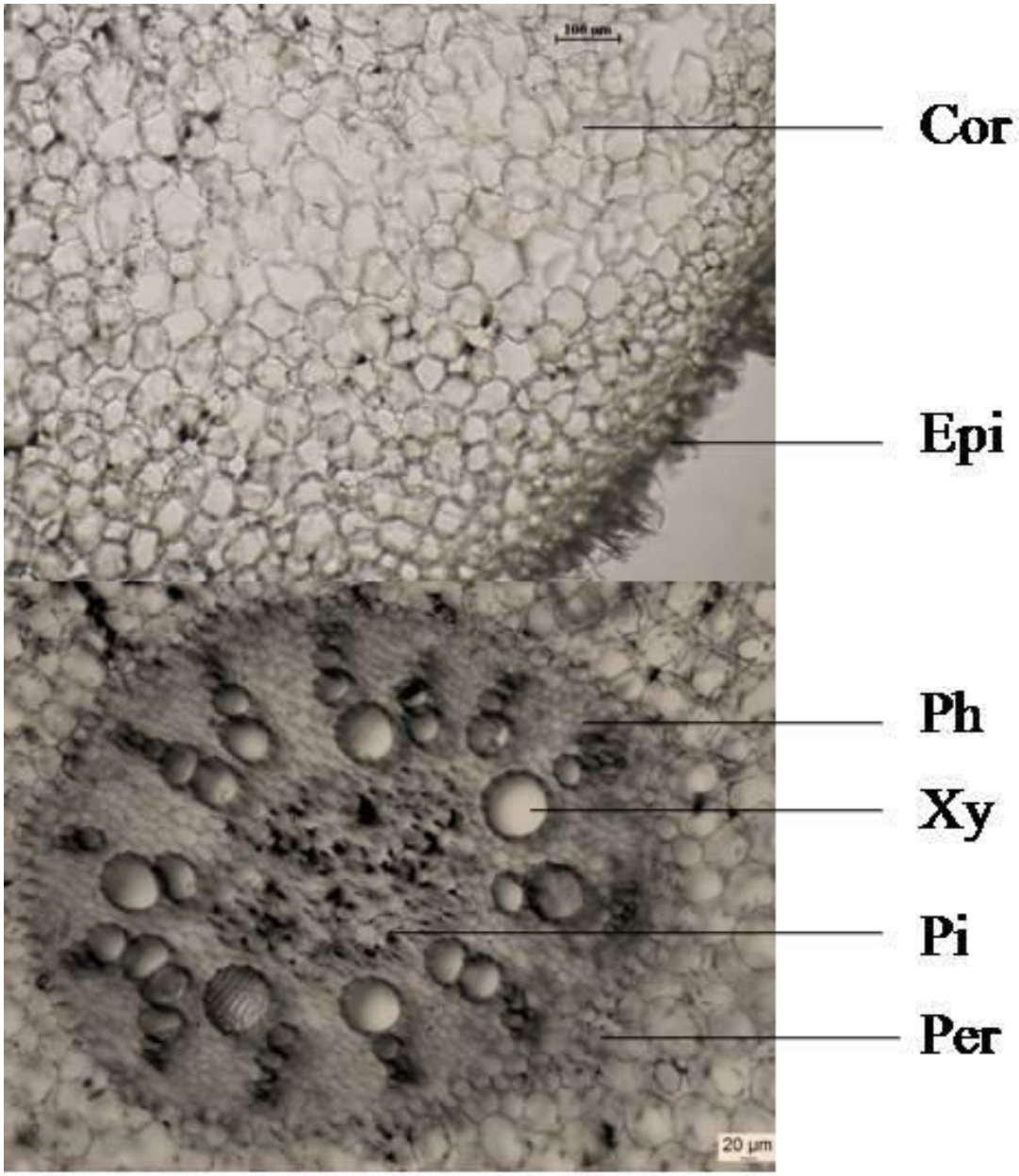


Figure 3.11: Transverse section of root of *C. asiaticum* of Kolkata provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

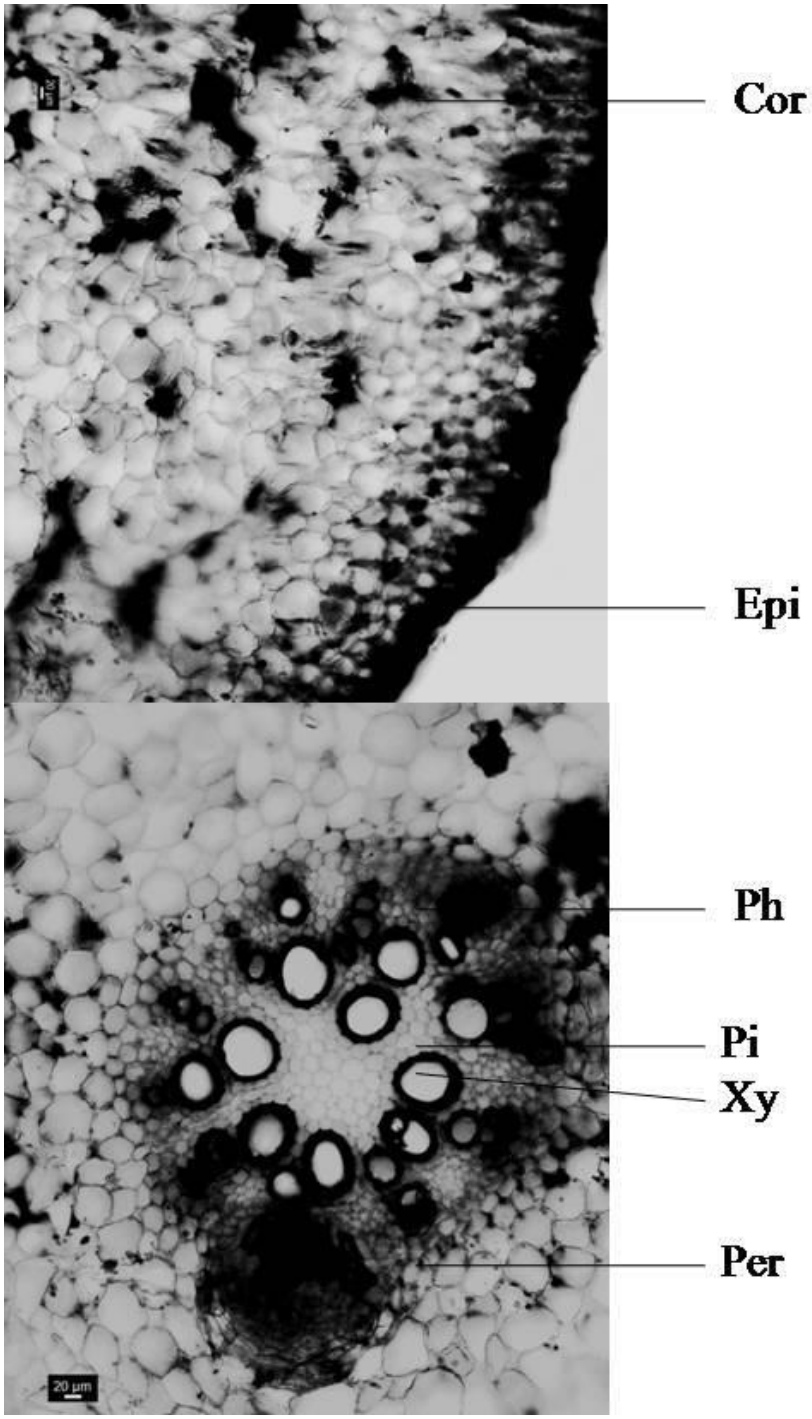


Figure 3.12: Transverse section of root of *C. asiaticum* of Mongpoo provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

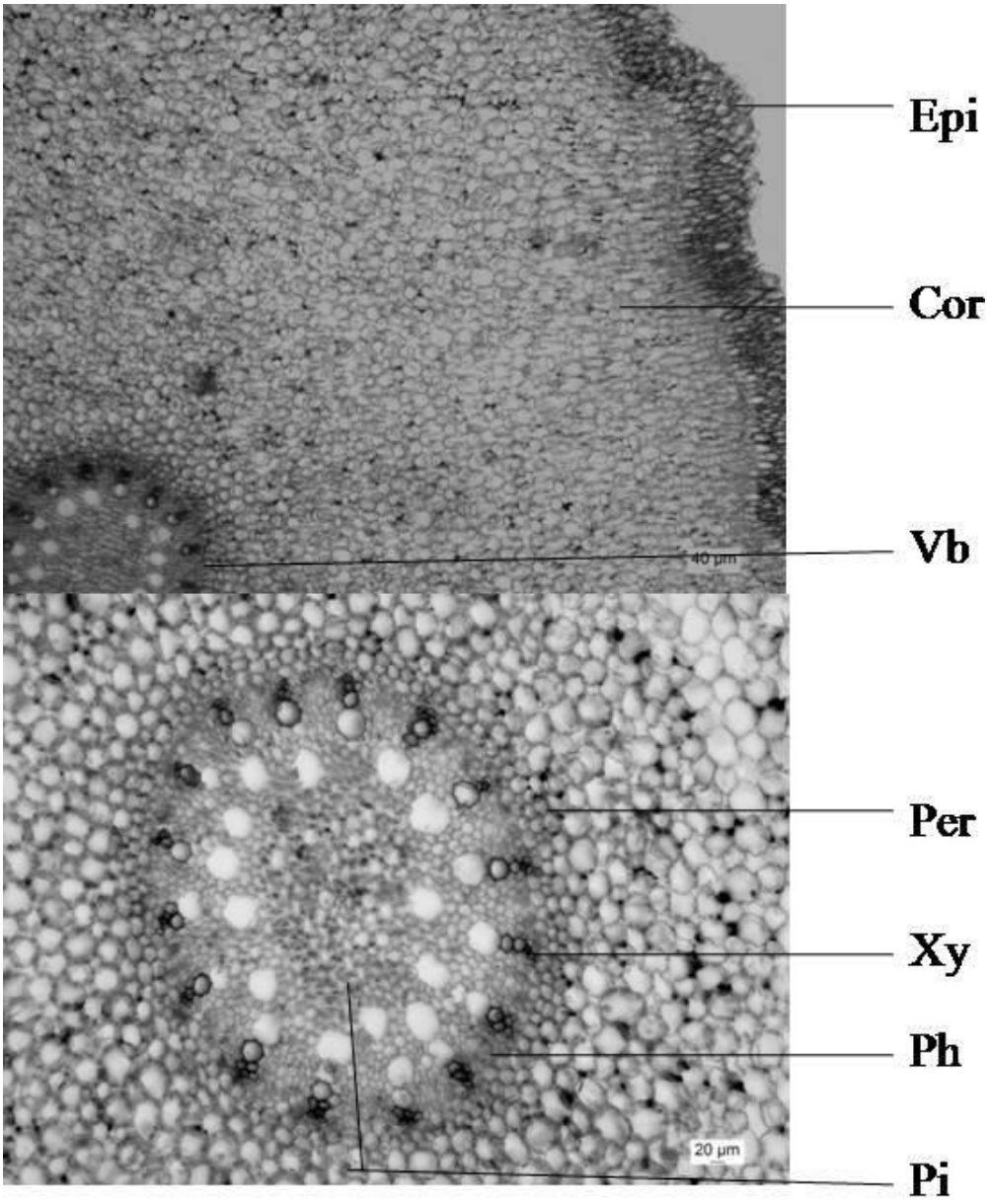


Figure 3.13: Transverse section of root of *C. asiaticum* of Nadia provenance.

(Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

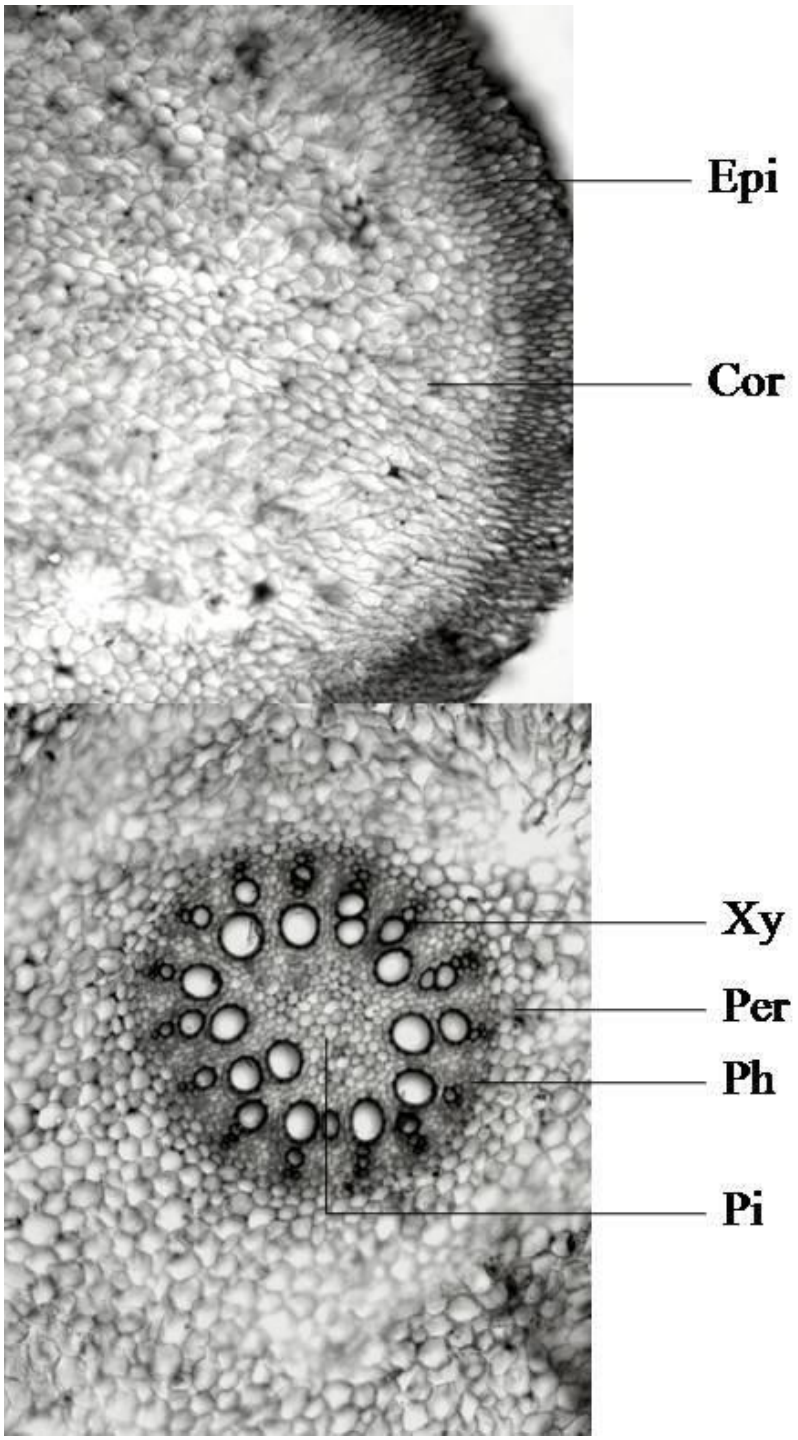


Figure 3.14: Transverse section of root of *C. asiaticum* of North 24 pargana provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

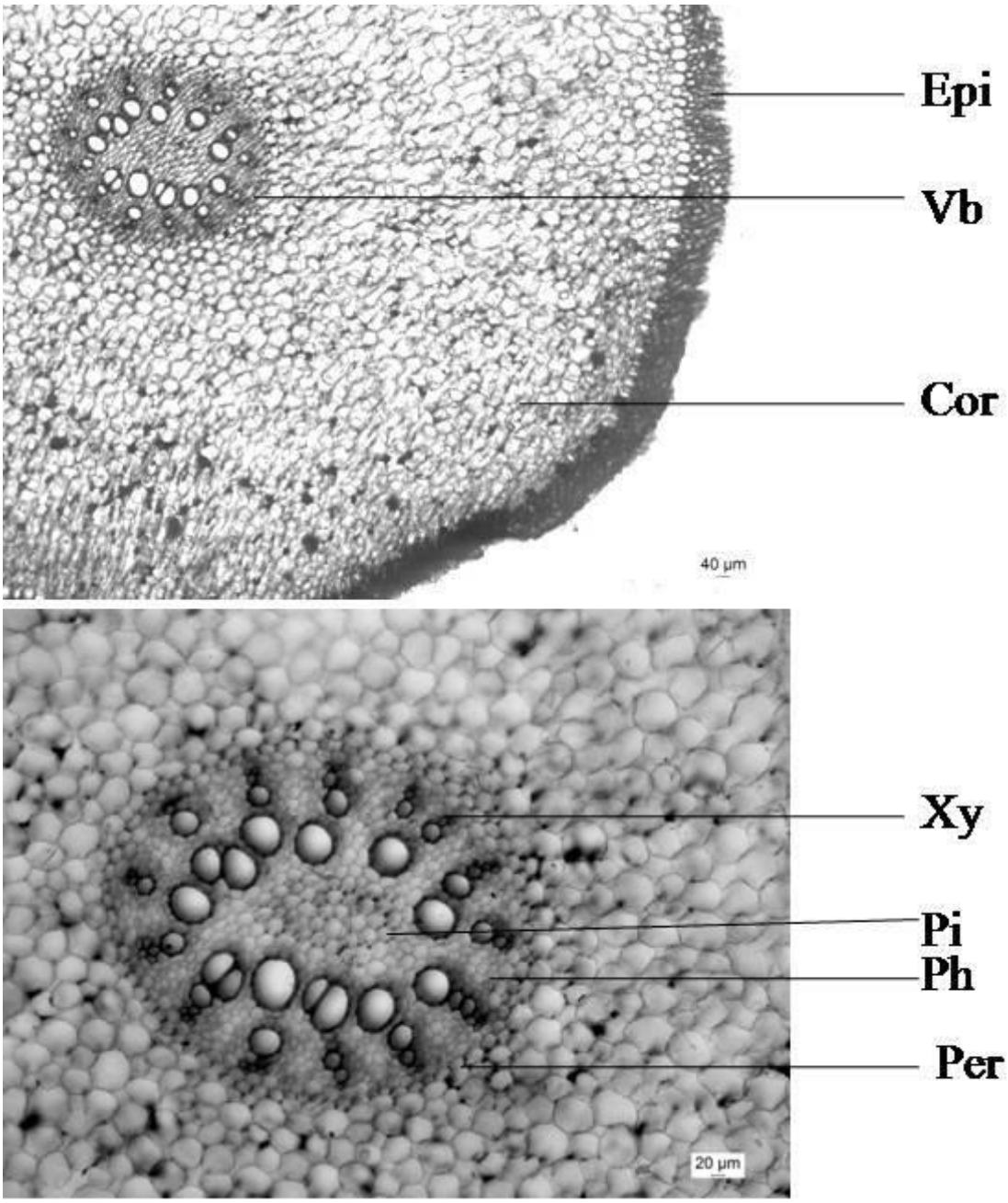


Figure 3.15: Transverse section of root of *C. asiaticum* of Paschim Medinipur provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

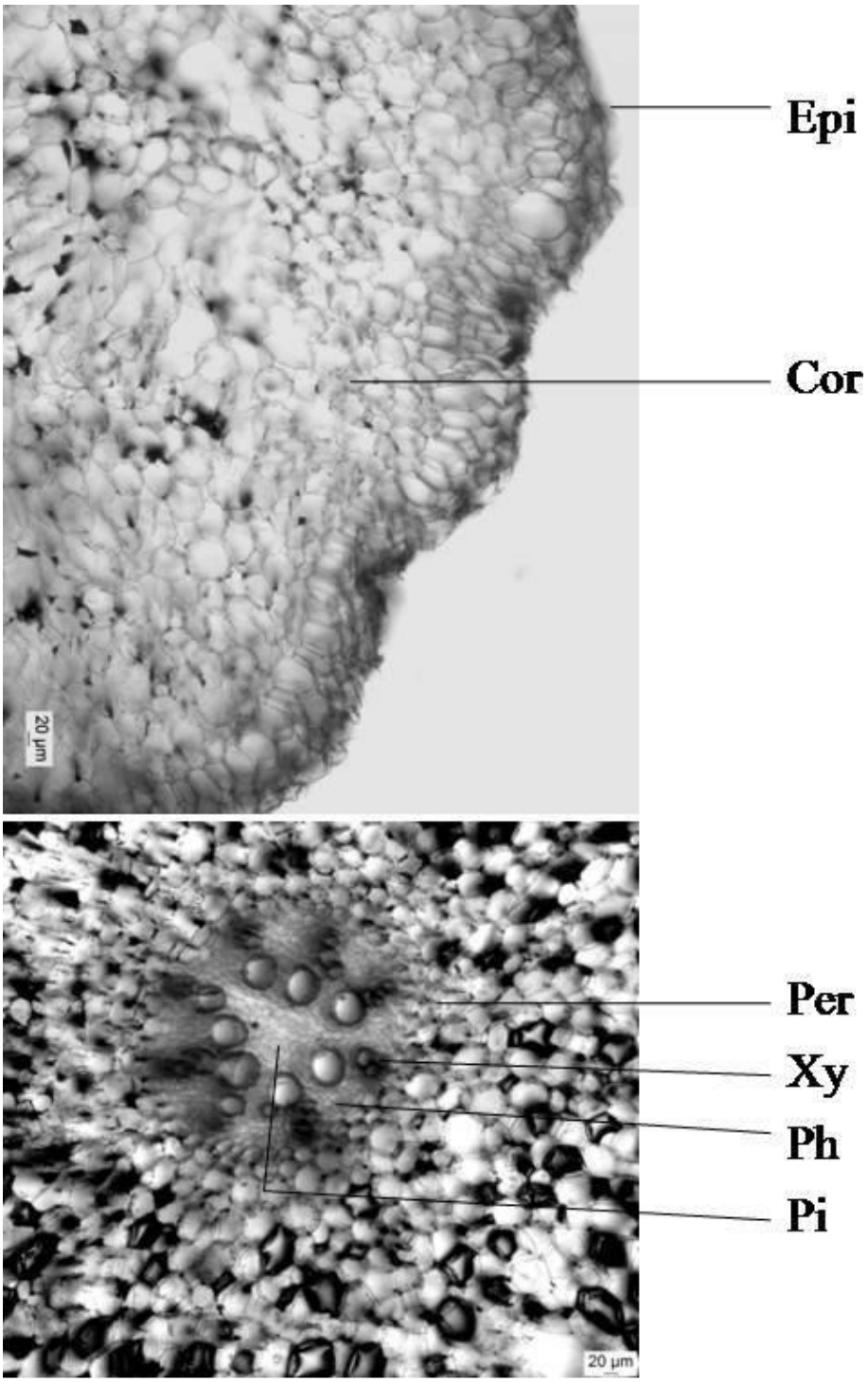


Figure 3.16: Transverse section of root of *C. asiaticum* of Purba Medinipur provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

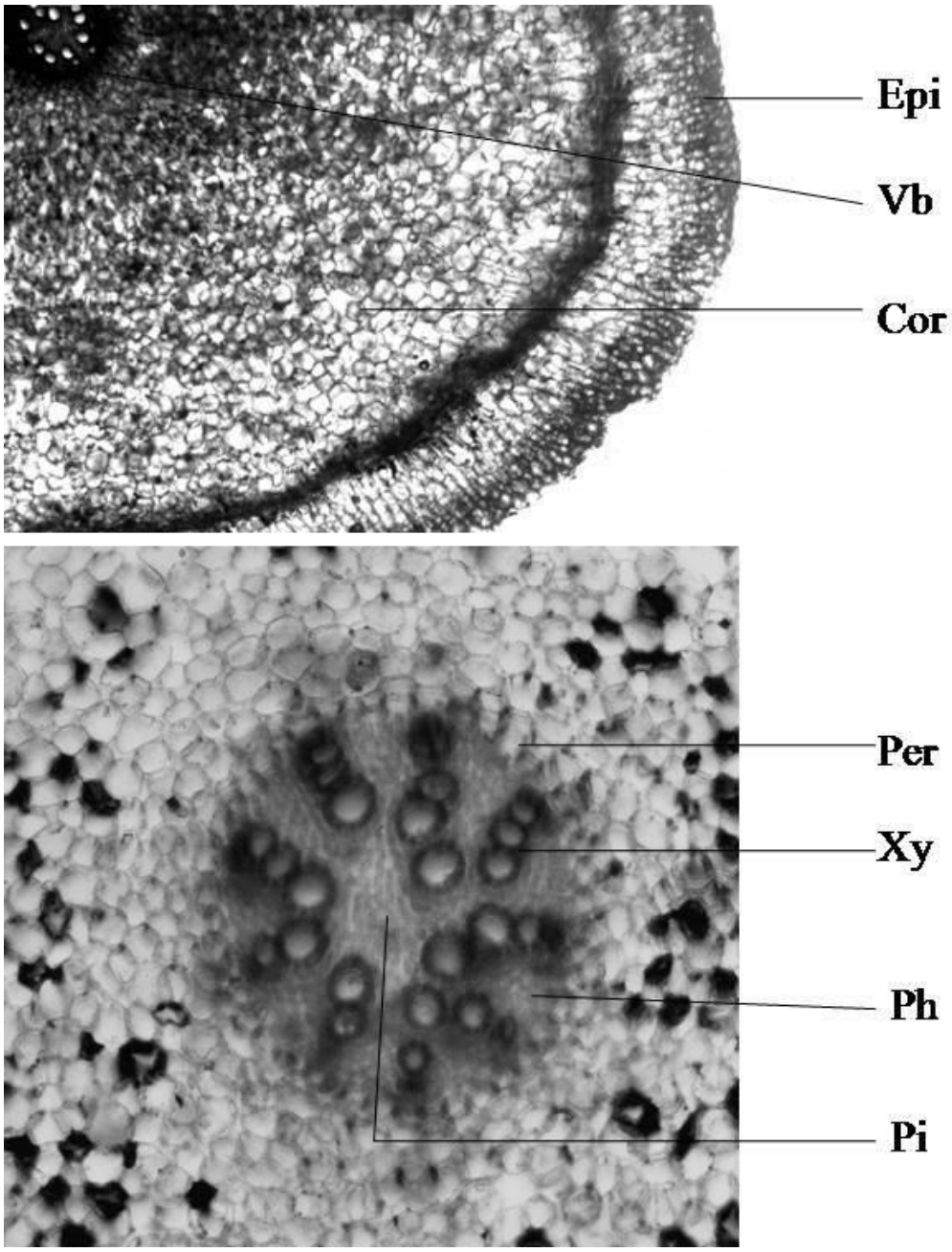


Figure 3.17: Transverse section of root of *C. asiaticum* of Shillong provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

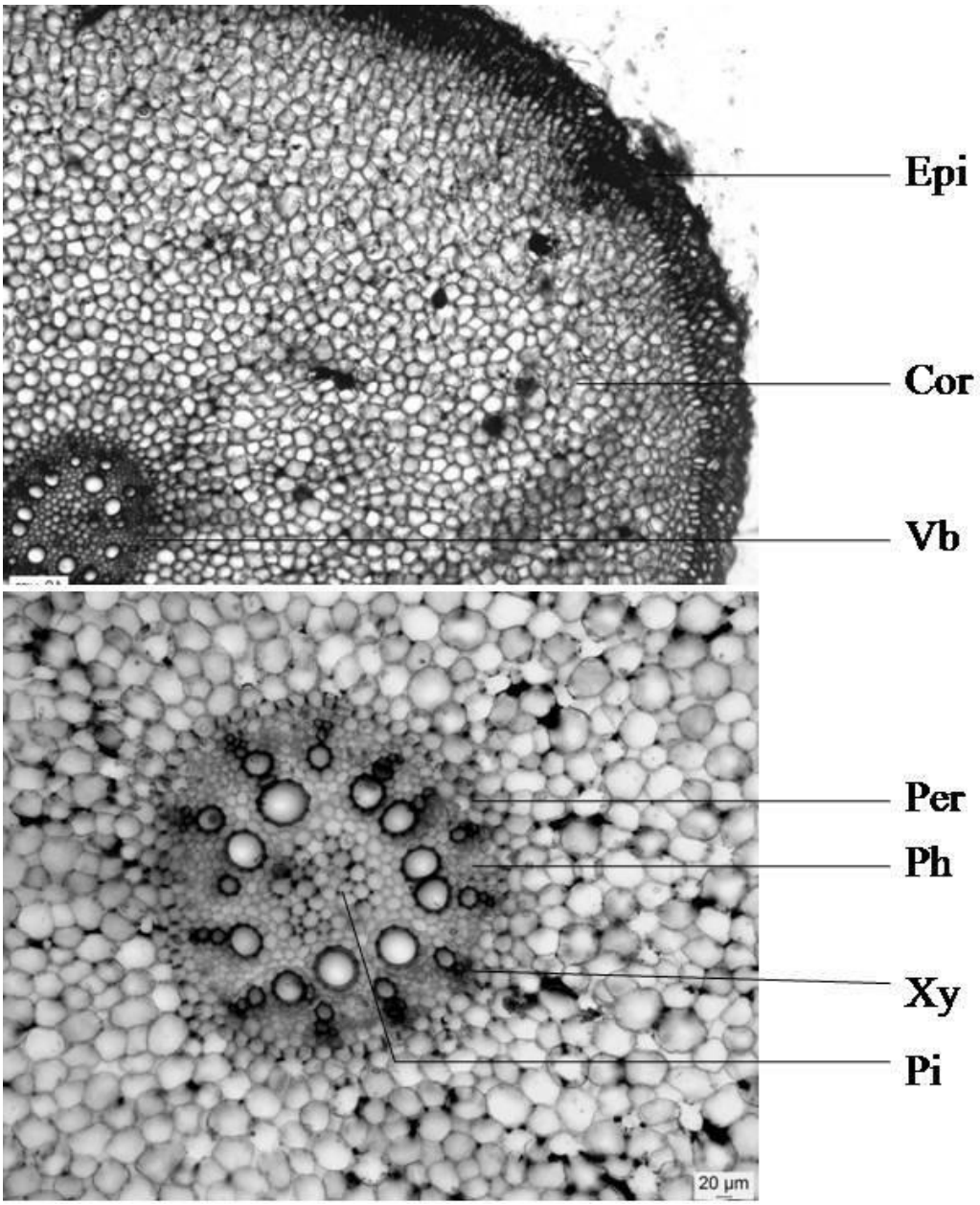


Figure 3.18: Transverse section of root of *C. asiaticum* of Sundarban provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

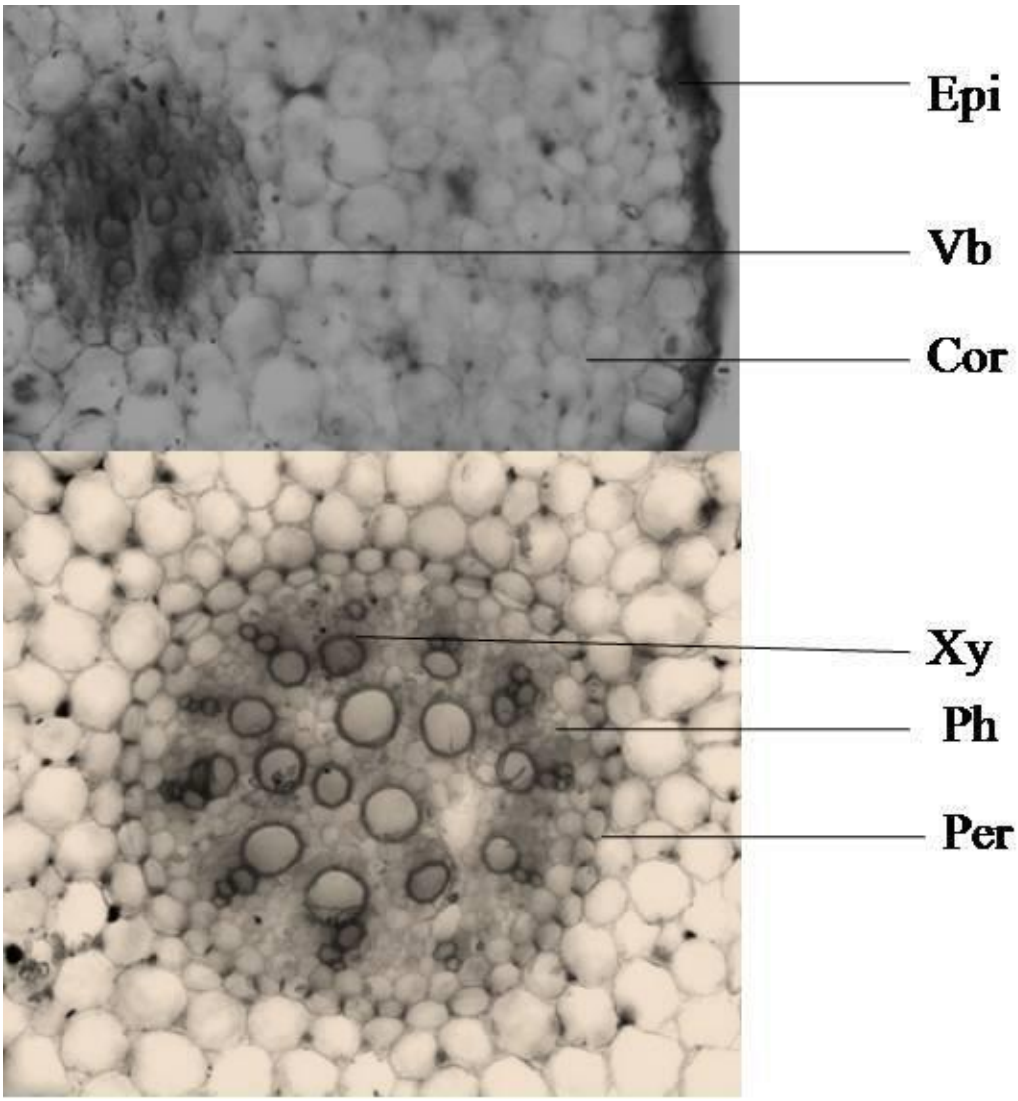


Figure 3.19: Transverse section of root of *C. latifolium* of Assam provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

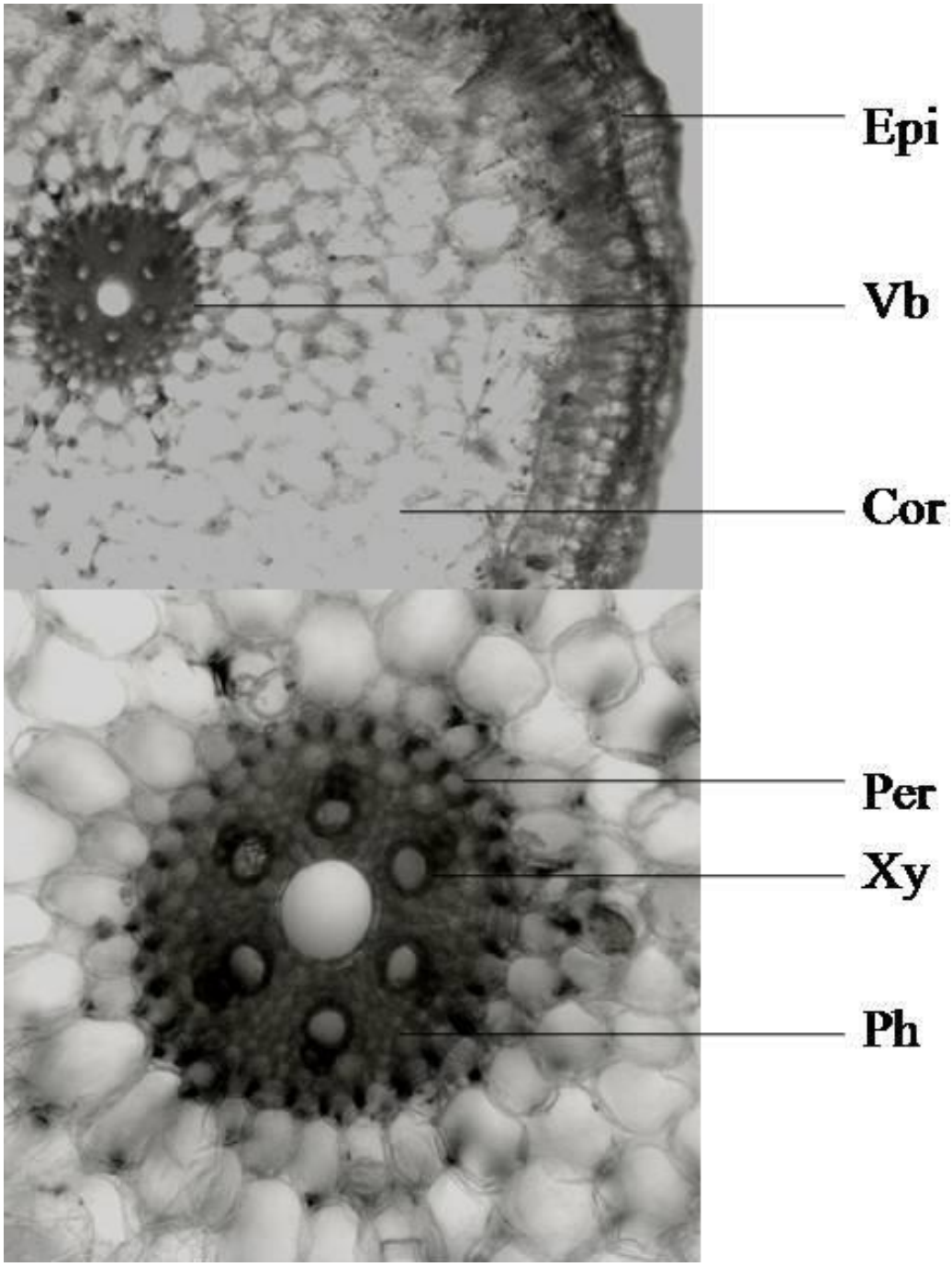


Figure 3.20: Transverse section of root of *C. latifolium* of Bankura provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

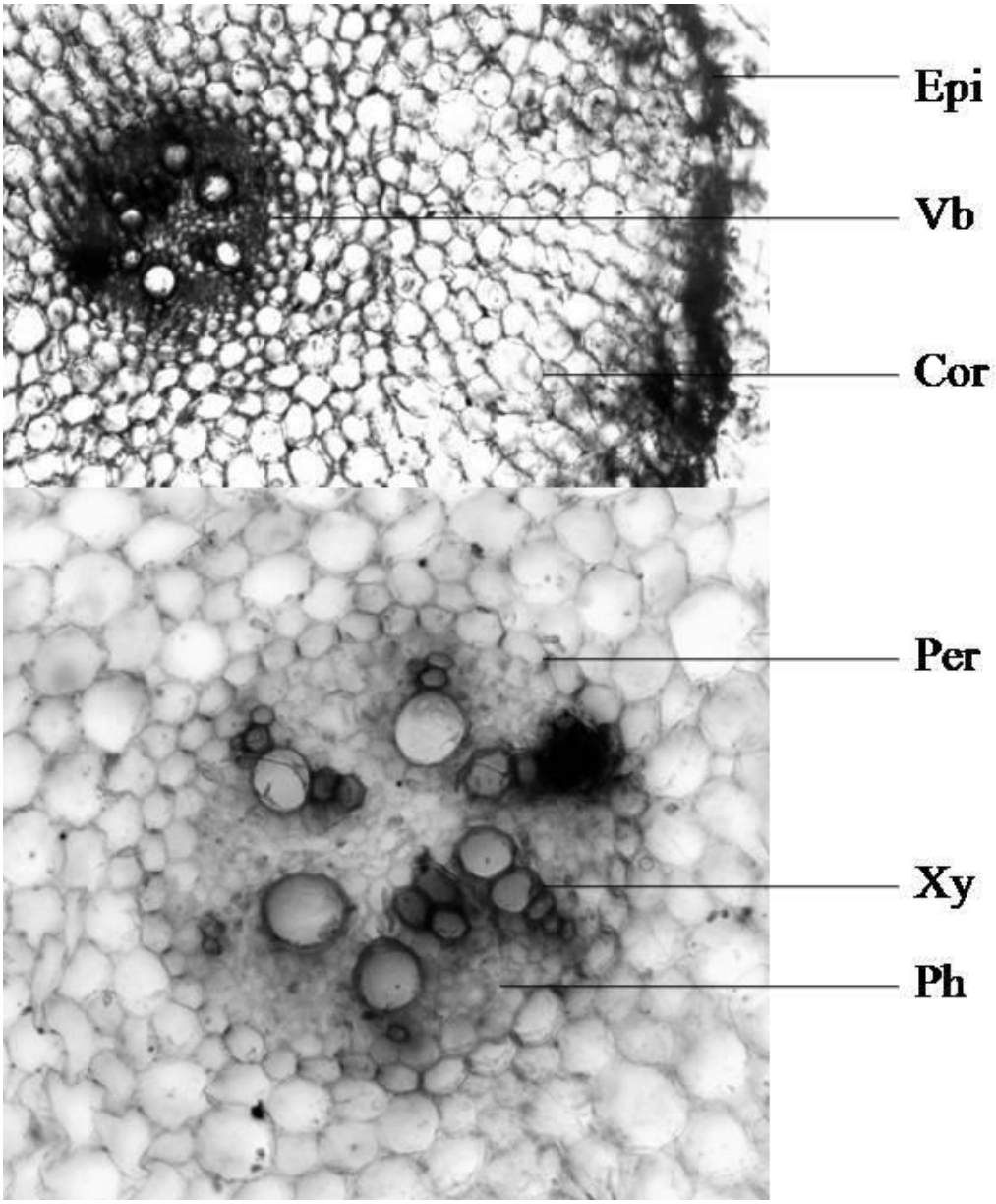


Figure 3.21: Transverse section of root of *C. latifolium* of Gangtok provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

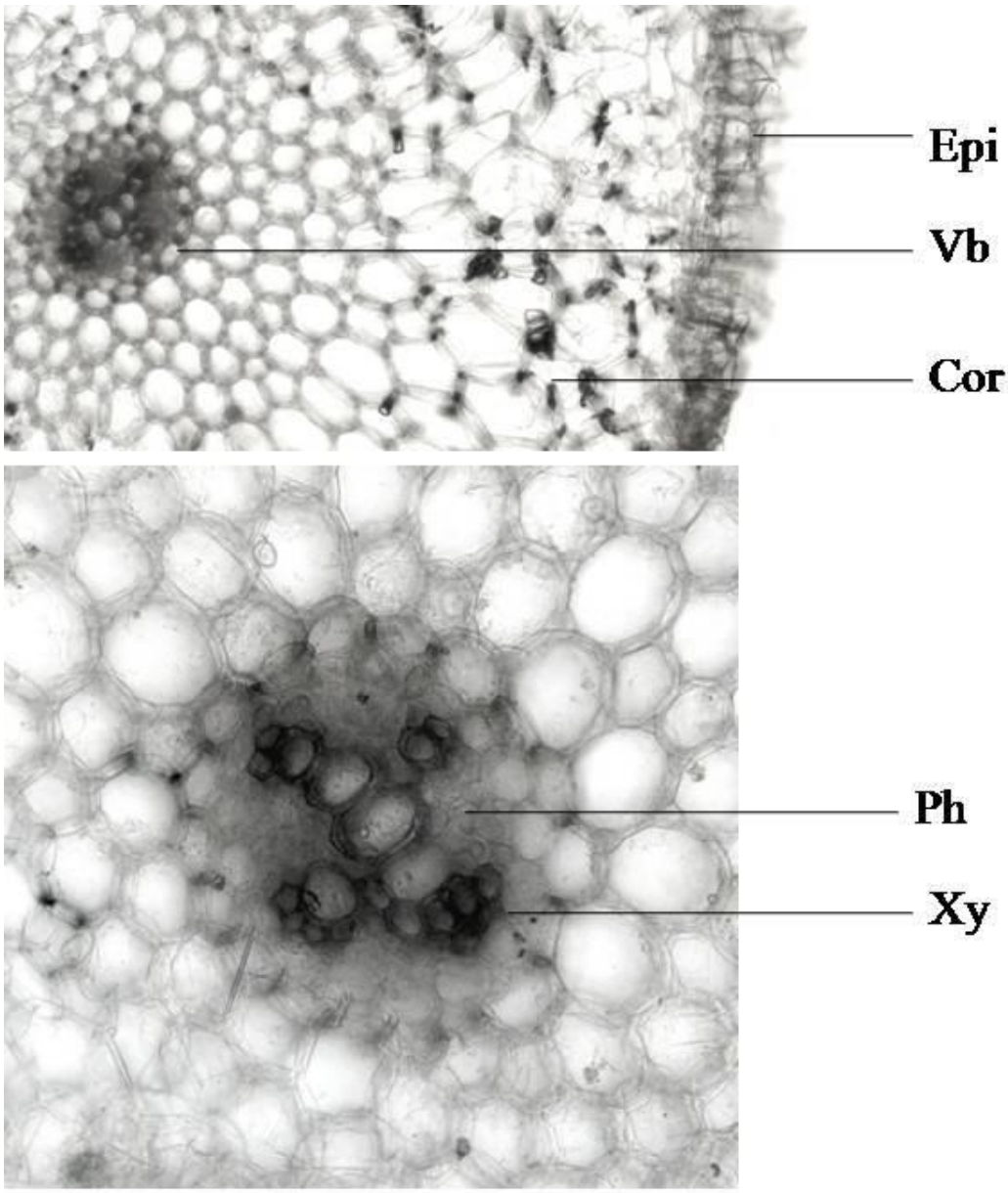


Figure 3.22: Transverse section of root of *C. latifolium* of Kashmir provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

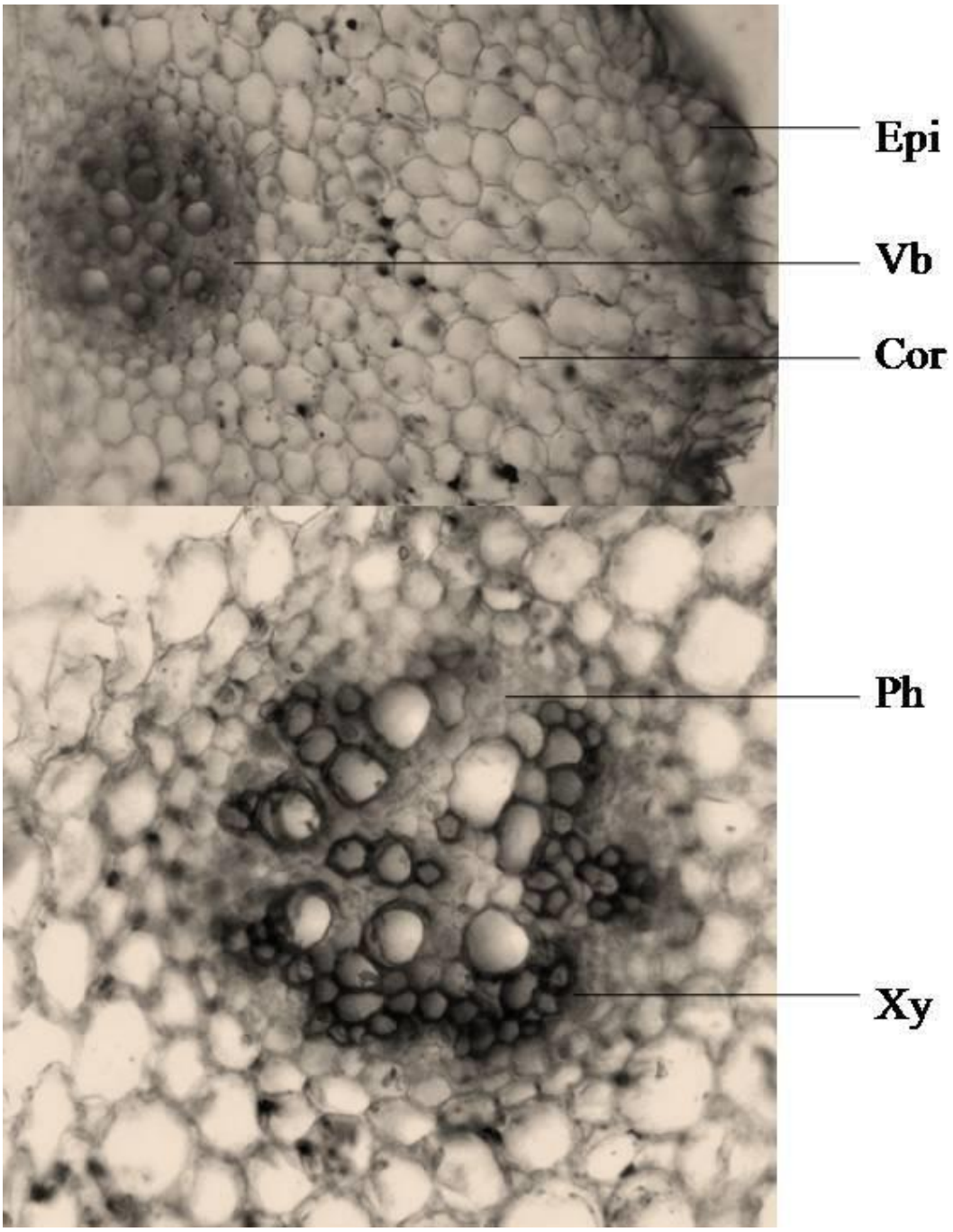


Figure 3.23: Transverse section of root of *C. latifolium* of Kolkata provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

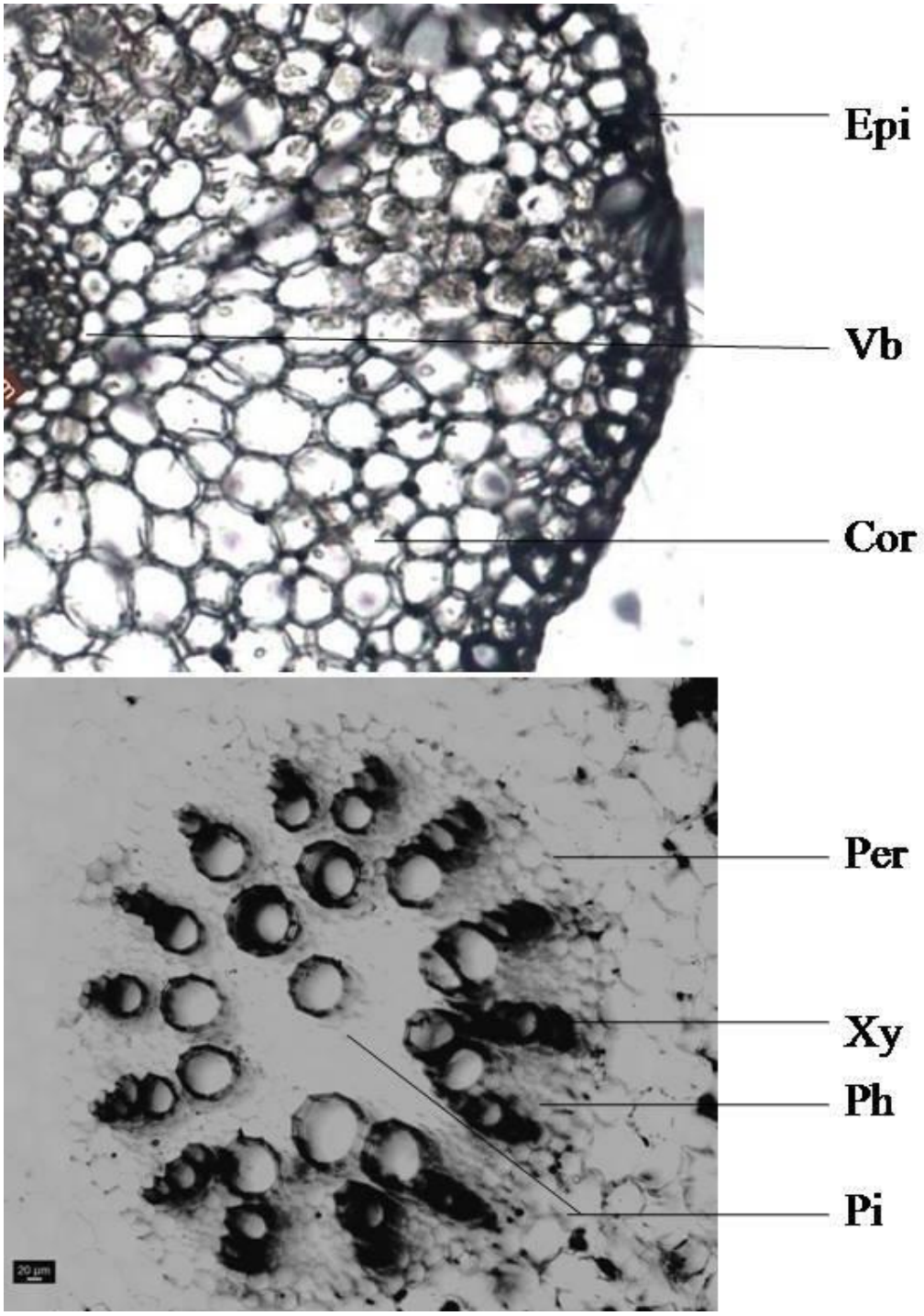


Figure 3.24: Transverse section of root of *C. latifolium* of Nadia provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

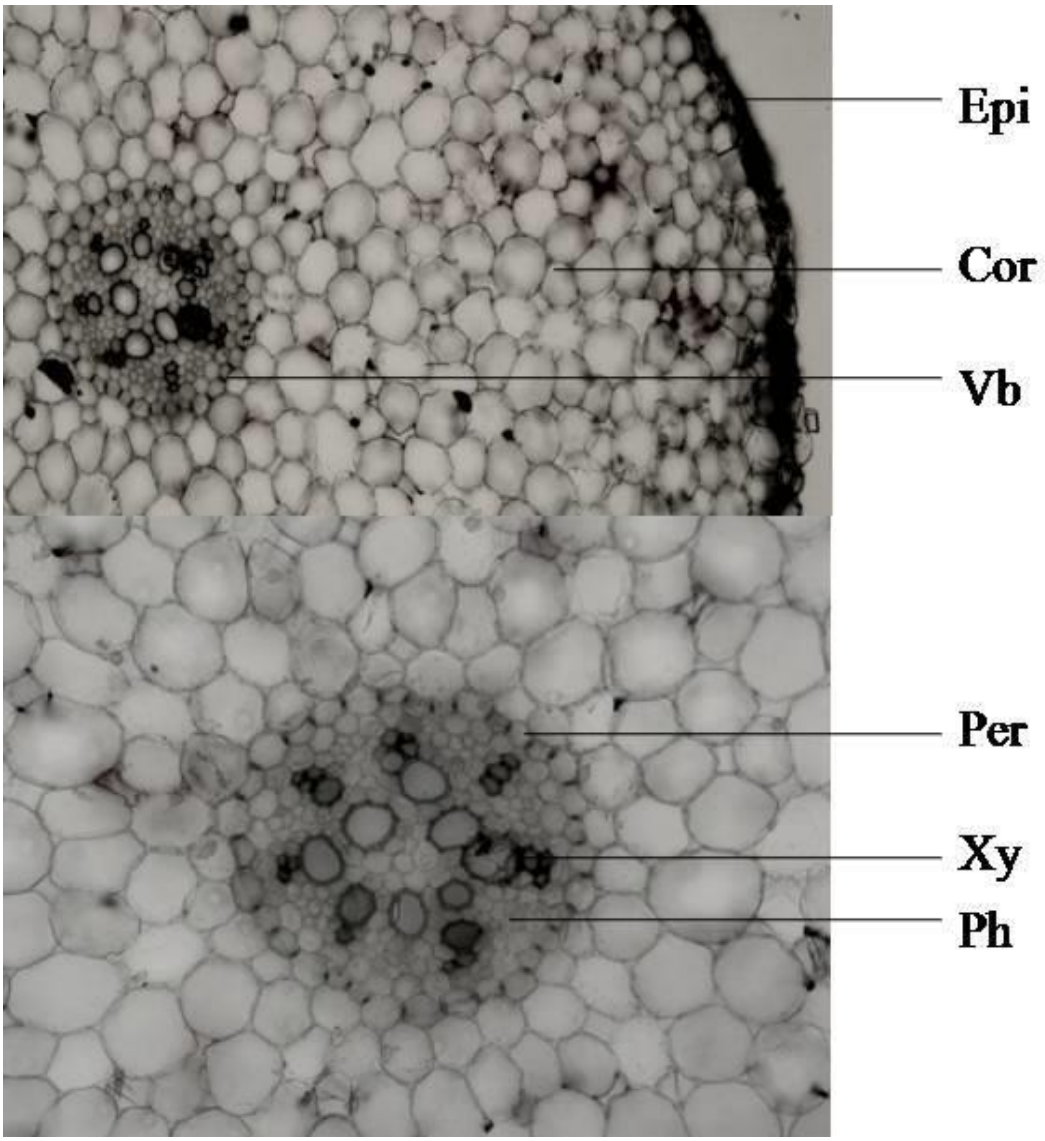


Figure 3.25: Transverse section of root of *C. latifolium* of Odisha provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

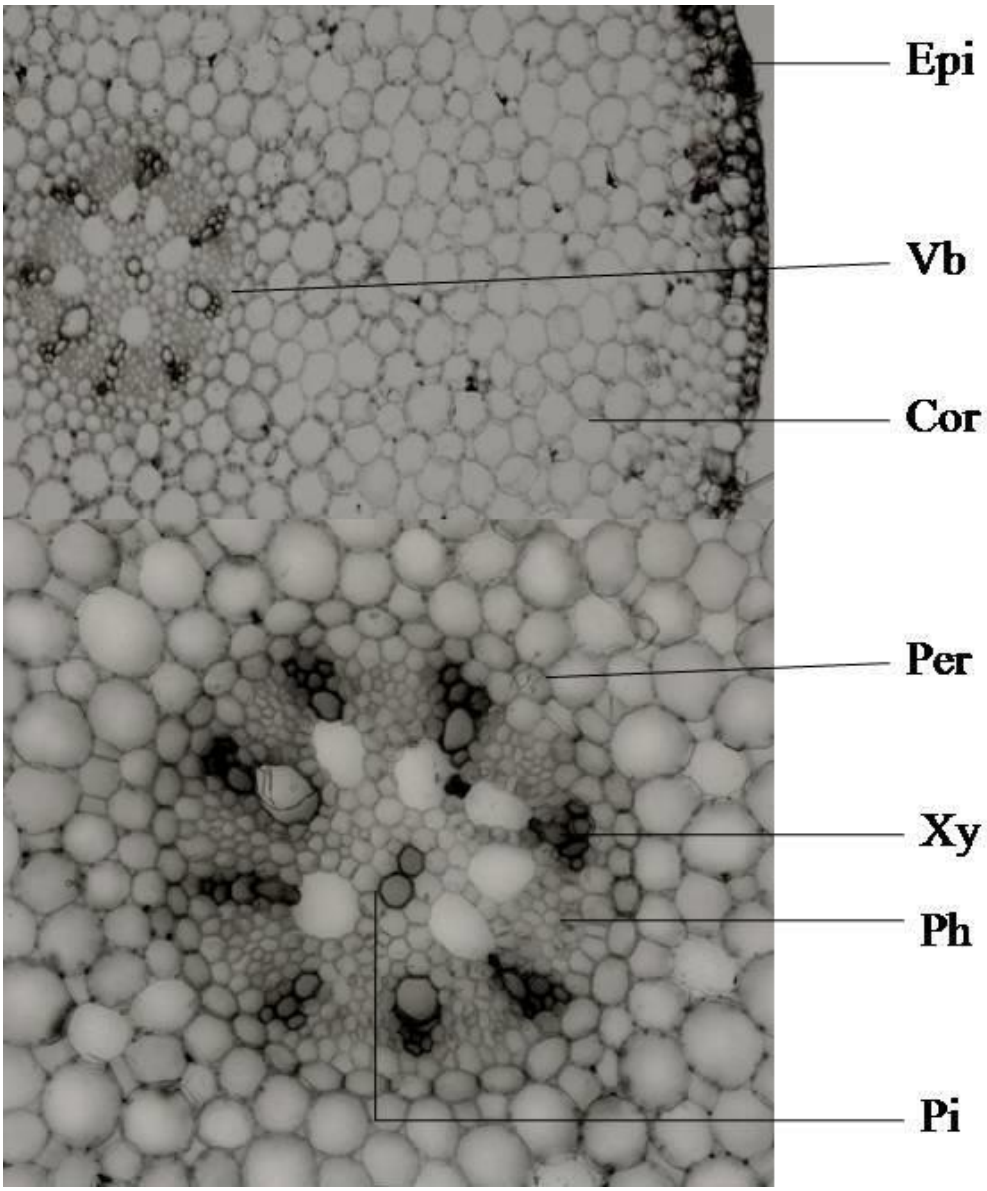


Figure 3.26: Transverse section of root of *C. latifolium* of Paschim Medinipur provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

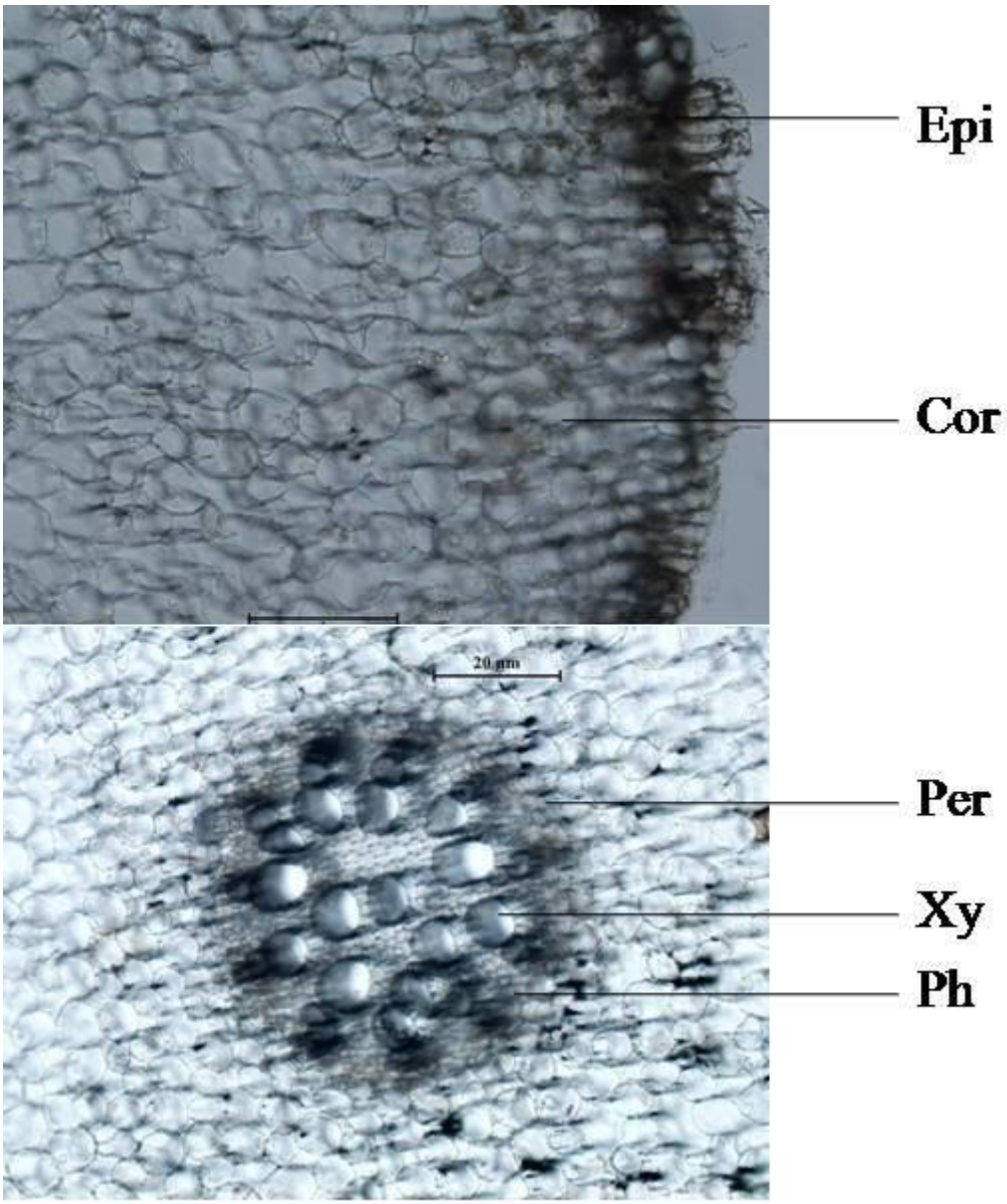


Figure 3.27: Transverse section of root of *C. latifolium* of Purba Medinipur provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

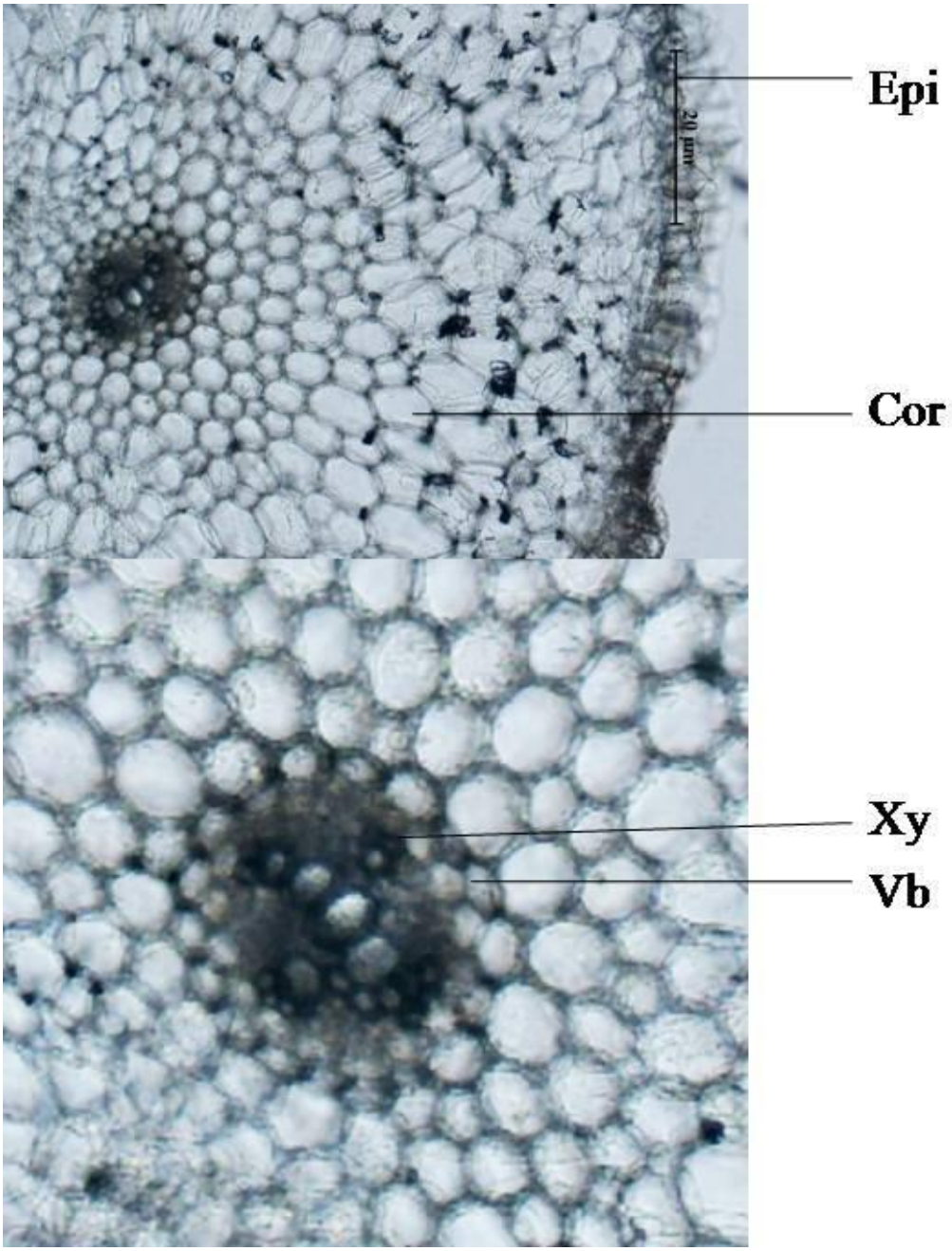


Figure 3.28: Transverse section of root of *C. latifolium* of Shillong provenance. (Epi – epidermis, Cor – cortex, Ph – Phloem, Xy – xylem, Pi – pith and Per – pericycle).

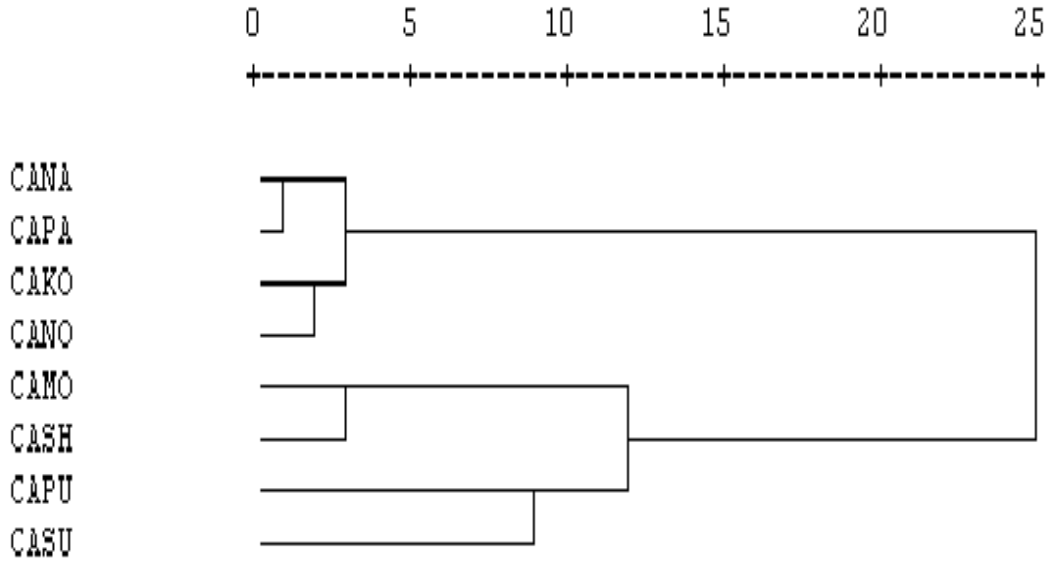


Figure 3.29: Dendrogram of *Crinum asiaticum* L. showing infraspecific relation among the different provenances.

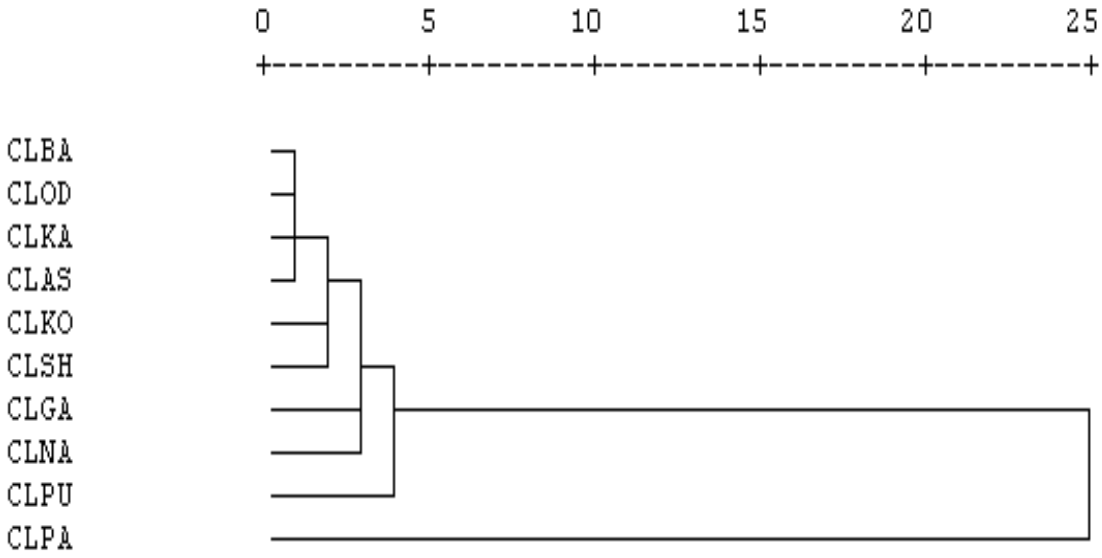


Figure 3.30: Dendrogram of *Crinum latifolium* L. showing infraspecific relation among the different provenances.

Discussion

The Phenological study of different localities of *Crinum asiaticum* L. is shown the close relationship at the time of bulb sprouting, vegetative activities and blooming time etc., but only *Crinum asiaticum* L. collected from North 24 Pargana have create the differentiation among the eight populations. On the other hand *Crinum latifolium* L. of ten provenances are shown same phenological characterization, but some of the population not creating fruit as like *C. latifolium* L. Assam, Bankura, Kolkata, Nadia, Odisha, Shilong. The details phenological studies are supported the view of germination, sprouting time and relatively fruiting time and time of inflorescence appearance are nearly similar in both the species. Some earlier worker have been supported our results (Olorode 1984, Snijman and Linder 1996, Hannibal and Williams 1998, Tram et al. 2002, Kwembeya and Stedje 2007, Patel et al. 2010).

External morphological appearance of *Crinum asiaticum* L. have shown the variation among the provenances in relation with plant height, growth diameter, phyllotaxy, shape of the bulb, neck of bulb, diameter of the bulb, leaf length, leaf width, scape height, no of flower per scape etc. (Table 3). Besides of this, reproductive structures of the species have shown the spectacular diversity among the provenances In *C. asiaticum* L. it is noted that *C. asiaticum* L. of Paschim Medinipur has shown the highest plant height (197.00 cm). Whereas *C. asiaticum* L. Mungpoo of Kalimpong having the lowest plant height only the 22.28 cm. (Table 3). Morphologically only the bulb character can distinguished themselves, out of eight provenance we can create it in three groups a- larger round neck, b- narrow round neck, c- absent of neck. Among the eight provenances only two

provenances namely *C. asiaticum* L. Shillong and *C. asiaticum* L. Mungpoo have no neck in the bulb (Table 3). The shape of the bulb from the eight provenances shows that only two *C. asiaticum* L. Shillong and *C. asiaticum* L. Mungpoo globose shaped bulb, rest of the provenances ovate shaped. *C. asiaticum* L. of North 24 Pargana has contained the highest scape height and number of flower per scape. The leaf anatomy of this species has shown the deviation only in two localities on shape of the vascular bundle and the number of the vascular bundle present in leaf (Table 6). In case of root anatomical study among the eight provenances only provenance of North 24 Pargana contain highest number of xylem strand in the vascular bundle (Table 8). The details such morphological characterization are not been published in early.

The other species *C. latifolium* L. among the ten provenances Purba Medinipur having highest plant height with growth diameter. But in respect of bulb morphology it is noted that only provenances of Kashmir have shown highly enlarged round neck in bulb. Among the ten provenances half of the provenances such as *C. latifolium* L of Gangtok, Kolkata, Paschim Medinipur, Purba Medinipur and Shilong have no neck in bulb. *C. latifolium* L. of Paschim Medinipur is shown the largest size of the bulb (Table 3.9). The provenances of Purba Medinipur having longest scape height. Here we noted that the color of the tepal are highly differentiated each other on the basis of tepal colour the total provenances of *C. latifolium* L. can be divided into four groups are is red tinted white colour, red tinted yellow colour, pink tinted green colour and four is white with pink stripe. Here it is also observed that shape of the perianth is also shown the diversity among the population (Table 3.9). The length of the filament attachment of the

anther are supported the diversity among the diverse nature. The leaf anatomy of *C. latifolium* L. has shown the differentiation on the presence of vascular bundle. In this case *C. latifolium* L. of Shilong have highest number of vascular bundle (Table 3.11). On the other hand root anatomical studies have supported the diversity among the provenances (Table 3.10 & 3.11). Earlier worker are found some differentiation related the study (Tram et al. 2002, Kwembeya and Stedje 2007, Patel et al. 2010).

Studied provenances of both species, collected from different localities, showed variations in gross morphological like leaf morphology, flower colour, other parameters and anatomical responses signifying the existence of inherent diversity at infraspecific level. Such diversity unfurls individual identity, too. Combination of multiple traits together generally gives stronger index to characterize the individuals of a locality of a species.

Different provenances of *Crinum* L. are shows gross morphological and a little anatomical resemblance, which differ them each other, this inter specific differentiation of the species. All the accession are shows differentiation in respect Plant height, growth diameter, bulb appearance in this context, shape of the bulb and upper part of the bulb both are created different group in the same genus in both the species. The workout revealed that in case of plant height all the eight provenances can be separated in two groups- one is so long, other is low in size. Among them *C. asiaticum* of Paschim Medinipur is shown highest plant height 197.00 centimetre, whether *Crinum asiaticum* shown the lowest height only 22.28 centimetre. Ovate shaped bulb are found in *C. asiaticum*, whether in *C. latifolium* have spherical. Interestingly upper part of the bulb i.e. neck of the bulb also created

a remarkable differentiation in between the provenances of same genus. In spite of bulb morphology other characters like leaf length, leaf width, leaf margin, shape of perianth, colour of flower, number of flower, aestivation and length of filaments are also differentiated them (Table 3.6 and 3.9). Previous workers have also revealed the morphological differentiation among the various species of this genus (Arroyo and Cutler 1984, Fangan and Nordal 1993, Snijman and Linder 1996, Meerow and Snijman 2001, Kwembeya and Stedje 2007, Bjora et al. 2009). In this study, it is noted that the bulb appearance is a most precise characteristic features in both the species. Here, it is also revealed that the six filament of a single flower of *Crinum latifolium* L. has been shown six different length and same result found in case of tepal also (Table 3.9). The details anatomical circumstances of the species has shown diacytic stomata present in both species, but shape of vascular bundle were different , *C. asiaticum* has shown ovoid shaped on the other hand *C. latifolium* with elliptical. Not only leaf anatomy but root microscopy also indicated differentiation among the provenances of the both species (Table 3.7 and 3.10). In this context, cortex region, numbers of xylem strand, diameter of stele are helps to point out them from the individuals. The details anatomical features has not revealed previously. Significance of anatomical information regarding species identification has been focused by earlier workers (Sharma et al. 2010, Kakrani et al. 2011, Mandal and Nandi 2012).

Conclusion

In this study both of the species have shown their intra and inter specific diversity in them. The morphological variance can indicate the ecotype or variety level in both. *Crinum latifolium* L. has showing thus a spectacular view of flower morphology. The study can help to understand the diversity, relationship and identification of both of the species.