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Research Article

A Review on Botanical and Phytochemical Characteristics of Grass Pea (Lathyrus Sativus L.)

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Abstract

Grass pea is an important crop of economic significance in India, Bangladesh, Pakistan, Nepal and Ethiopia. It is adapted to arid conditions, contains high levels of crude protein (26-32%), requires little water, and is sown with wheat as a Para-crop. To produce a proper Botanical delimitation of *Lathyrus sativus* L., morphological attributes from seed to mature plant were recorded at different leaf stages. The morphological parameters discussed are germination, root, root nodule characters, cotyledon, epicotyl, phyllotaxy, leaf petiole; stipule and leaf blade (type, shape, size, base, apex, margins, surface, color and venation), flower (inflorescence, number, color and parts), fruit and seed (shape, size, surface and color) along with some statistical observations of vegetative and reproductive growth were observed keenly. From renowned publications, citations have been made for anatomical, palynological and phytochemical information of *L. sativus*.

Keywords: *Grass Pea, Lathyrus sativus L., Morphology, Phytochemical, Taxonomy.*

Introduction

Legumes in plant taxonomy are considered as one of the large and heterogeneous family. As best for study, it is divided into three separate sub-families of order Fabales: Mimosaceae, Caesalpiniaceae, and Papilionaceae comprising about 560 genera and 13,200 species in whole (Hutchinson,1973 and Cronquist,1981). Economically the cultivated varieties of the group are essential for their high protein content. The family is characterized by their defined floral and fruiting characteristics by other families, yet there are so many taxonomic implications within the members, still stand as a major problem for taxonomist and so any new botanical information about Fabaceous genera is urgently to be welcomed.

This work is so confined to *Lathyrus sativus* L. as a plant commonly adapted to arid condition and now a day show more potentially adaptive crop in developing areas. However, the cultivation of grass pea was, banned in India on account of spread of lathyrism, which causes paralysis and muscle atrophy of lower limbs due to consumption of a diet consisting of about 25% *lathyrus* for a period of 2-6 months (Williams *et al.,* 1994; Smartt *et al.,* 1994). Occasional use is harmless. Seeds, if soaked in water for 24 hrs. before cooking, are not toxic (Duke, 1981).

The genus *Lathyrus* constitutes 187 species and subspecies but only *L. sativus* is widely cultivated as a food crop (Jackson and Yunus, 1984). This widespread distribution is due to its extensive utilization as a fodder crop and its tolerance to adverse environmental conditions such as drought and water logging (Jackson and Yunus, 1984; Smartt, 1990). It is also reported to exhibit tolerance to abiotic factors such as heavy soils, high pH, low pH, poor soil, and to biotic factors such as rust and virus (Duke, 1981). The total number of grass pea accessions maintained at the International Center for Agricultural Research in the Dry Areas (ICARDA) was 301, most of which are weedy forms found in crop fields and West Asia and North Africa regions. Some species are valued as ornamental plants, especially the sweet pea (*L. odoratus*). Grasspea is found in Eurasia, North America, temperate South America, and East Africa (Smartt, 1990).

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The origin of *Lathyrus sativus* is unknown; however, its presumed center of origin is Southwest and Central Asia (Smartt, 1990). Its chromosome complement is $2n = 2x = 14$ (Smartt *et al.,* 1994).

The seeds are boiled and consumed as a pulse, and can be used in dal preparation and bread making. Higher crud protein content is important for feeding animals; however, the quality of proteins depends on their amino acid content, particularly essential amino acids. They are made into paste balls, put in curry, or boiled and eaten like a pulse. "Grass pea seeds are used in India, Ethiopia and other developing countries as part of the diet of the poor in times of famine. Leaves can be used as a vegetable after boiling. "Plants are valued for green manure but have weedy tendencies. Mixed with oil cake and salts, seeds are used as a nutritive feed for poultry and livestock. Primarily grass pea is cultivated as a cold weather forage crop". Traditionally the Oil from the seeds of grass pea used as a powerful and dangerous cathartic that contains a poisonous principle, probably an acid-salt of phytic acid. The seeds are used locally in homeopathic medicine" (Duke, 1981). Grass pea is reported to add 67 kg per hectare of nitrogen to the soil from symbiosis with *Rhizobium* sp." (Kay, 1979; Duke, 1981; Campbell *et al.,* 1994).

This work aims to provide detailed botanical information about the external morphology of vegetative and reproductive growth of the whole life span of *Lathyrus sativus* L. This work also includes a short review of the pollen study, anatomy, phytochemical, and pharmacological studies on *Lathyrus sativus* L.

Materials and Methods

The present module was carried on a common winter crop field weed *Lathyrus sativus* L (Fabaceae), commonly called Grass pea (UK and N. America), Khesari or Batura (India), Guaya (Ethiopia), Matri (Pakistan). Seeds of the plant were collected from the different crop fields of the study area followed by correct identification of the plant taxa. All experimental work was done in botanical garden, Department of botany, Sunbeam Women's College Varuna, Varanasi, U.P., India in the year 2022-2023. Date of seed showing was November 3rd 2022 during starting of the winter season (Panda *et.al.,* 2021). The work trial containing 5 replicates of each pot having more than 30 plants and two plants from each replicate were observed for different data at every leaf stages.

All the morphological observations done from the germination of seed and at every leaf stage till maturity by stereomicroscope (Olympus-Magnus MSZ-Bi), statistical observations of underground and aerial vegetative growth were taken, the following used parameters are:

- Number of days of occurrence of different leaf stages
- Total aerial plant height at different leaf stages (in cm)
- Total underground plant height at different leaf stages (in cm)
- Length of internodes at plant maturity (in cm)
- Total number of internodes of the main stem at plant maturity
- Total number of secondary, and tertiary branches occurred at different leaf stages
- Total length of secondary, and tertiary branches at maturity
- Fresh weight of leafless shoot at maturity
- Dry weight of leafless shoot at maturity
- Number of leaves per plant
- Total leaf area per plant (in cm^2 by Systronics Leaf Area meter 211)
- Fresh weight of leaf per plant
- Dry weight of leaf per plant
- Similarly, statistical parameters taken for reproductive growths are:
- Number of mature dry pods per plant
- Number of seeds per pod
- Total number of seeds per plant
- Dry weight of pods per plant
- Yield of mature dried seeds per plant
- Specific weight of seeds (average of 100 seeds)

Other attributes such as Anatomy of root and stem, leaf surface morphology, Palynology, Karyotype study, and Phytochemical studies are cited from renowned publications on *L. sativus*.

Observations

Morphological Characters: Morphological observations were recorded from the beginning of germination, seedling, and flowering stages under the following subheadings.

Plant annual, herbaceous, prostrate, and much branched. Seedling horsfeildia type (Vogel, 1980). Primary root non-fibrous, tap root, much branched, more developed in early stages, equally developed and then lesser development in latter stages than shoot, milky white to light yellow, glabrous terete in cross section and secondary roots slightly zig-zag in advance stages, secondary branches more in number at top of the root. Root Nodules appeared after 3rd leaf stage; nodules were irregular, light pink, and glabrous. Collet and hypocotyl not distinct. Cotyledons two, secund, cryptocotylar (just below the soil/ at just soil level), isocotylar, fleshy, persistent up to 11th leaf stage, exstipulate and sessile. Blade sub-orbicular 0.5-0.6 X0.5-0.6 X 0.1 cm, mean L/W (Length and width ratio) 1.0, base rounded, apex truncate, margins entire, both surfaces milky white-light yellow and glabrous, plano-convex in cross-section, enclosed within brown-black testa; seed coat persistent up to 10th leaf stage. Venation is not distinct. Epicotyl purple-white and slightly terete below, green and quadrangular up to 2nd leaf stage, quadrangular and winged from 2nd to 8th leaf stage and compressed/wings more pronounced after 8th leaf stage (sometimes sparsely hairy at 12th or 13th leaf stages). Prophylls two, alternate, sessile, base truncate, apex trilobed and apiculate, green, and glabrous, *ca* 0.4 cm long. First leaf bifoliate, compound, alternate, stipulate, and petiolate. Stipules 2, free lateral, lanceolate, base cuneate in first leaf but semi-sagittate afterwards, apex acute, margins entire, both surfaces green, glabrous, and vein less. Petiole green, glabrous, convexo-concave in cross section winged after 6th leaf stage, prolonged into mucro up to 5th leaf stage but petiole mucro modified into tendrils after 5th stage. Tendrils acicular, green, glabrous and coiled at apex, *ca* 1.8 cm long. Leaflets 2, opposite, exstipulate, and sessile. Blade linear *ca* 2.0-6.0 X 0.3-0.9 cm, mean L/W 6.7, base and apex acute, margins entire, both surface green and glabrous. Venation acrodromous; multicostate reticulate, 3 primary vein distinct, reaches to blade apex. Leaves up to 11th leaf stage same as 1st leaf but in the 12th and subsequent leaves tendrils trifurcate and are more coiled at the apex, each tendril branch *is* 2.8 cm long.

Flower buds appear at the 12th leaf stage. Inflorescence axillary and solitary; buds yellow-green. Flowers pentamerous, hermaphrodite, irregular, complete, zygomorphic, perigynous, and pedicellate. Pedicel pink-green, glabrous, terete in cross-section, *ca* 0.8-3.0 cm long. Epicalyx two, fused, scaly, light pink, glabrous, < 0.1 cm. Calyx gamosepalous, inferior, campanulate; fused in half length; sepals 5, each lanceolate *ca* 0.8 X 0.3 cm, mean L/W 2.7, base truncate, apex apiculate, both surfaces green and glabrous with pink notch at the junction of two sepals, single nerve present. Corolla polypetalous, papilionaceous, descending imbricate, inferior, petals 5; standard petal obcordate, *ca* 1.0 X 1.3 cm, mean L/W 0.8, base cuneate, apex emarginate, margins entire, adaxial surface dark blue with pink white eye below, abaxial surface coppery red-purple, both surfaces glabrous, venation fissured, multicostate reticulate; wings petals, lateral one on each side of standard, obovate *ca* 1.0 X 0.6 cm, mean L/W 1.7, base cordate-attenuate, apex obtuse-truncate, margins undulate, both surfaces blue with a white-pink line on upper margins, veins as in standard petal; and keel lower anterior fused in a boat shape, elliptical, *ca* 0.7 X 0.2 cm, mean L/W 3.5, base semisagitate, apex apiculate, margins entire, both surfaces translucent white, veins not distinct. Androecium diadelphous, stamens 10 (9+1 pattern), basifixed introse; enclosed in keel and covering the gynoecium, Anthers dithecous, yellow, glabrous. Pollen grains are light grey, oval, and glabrous. Gyneocium carpel one, obary superior, unilocular with 1-4 ovules, placentation marginal, green, fusiform-oblong and flat, suture ribbed on dorsal side and entire on ventral side, *ca* 0.5 cm long, surfaces hairy; hairs multicellular, bas broad, apex glandulate, <0.1 cm long; style green, winged and hairy, *ca* 0.3 cm long; stigma terminal, spathulate, greenish, viscous and hairy, *ca* 0.3 cm long.

Fruit simple, dehiscent legume with persistent calyx and style, Pod green in early stage and turned to yellow-brown at maturity, splitting along both sutures, elliptical-oblong, *ca* 2.5-3.5 X 0.9-1.2 cm, mean L/W, 2.8, base cuneate-oblique, apex apiculate with a sharp pointed tip, bulging on one side, swollen throughout, surface glabrous and reticulately, veins, 3-5 seeded.

Seed ex-albuminous, green/grey/brown/red or yellow, suborbicular or spherical, *ca* 0.5cm X 0.4cm X 0.4cm, mean L/W 1.1, base and apex rounded-truncate, faces convex or depressed with black mosaic patches, glabrous. *Hilum* distinct in shallow notch, dark black-brown, oval with central median line.

Germination and seedling: Seeds germinate after 4th day of sowing, germination was hypogeal or just at soil level, the hypocotyl and collet not distinct at all in the seedling, seed coat persistent, covering the cotyledons and hence the germination type referred as Horsfeldia type (Vogel, 1980). The germination of the grass pea seed is 86 % showing high viability of seeds.

Root and shoot growth: Roots in the early stage of the seedling grow fast than shoot as R/L (root shoot length ratio) was found 5.03 the mean value; equal growth as shoot system at 1st and 2nd prophyll stage with numerous secondary roots, having mean R/L value 1.12-1.07, less growth than shoot afterward and having R/L mean value 0.6 to 0.5 up to 4th leaf stage and slightly increasing from 0.6 to 0.7 till maturity. The lateral roots after **3rd** leaf stage, bear numerous spherical-oval to irregular shaped root nodules. The shoot growth increased consistently throughout the entire life span and reaches its maximum length of 30.6 cm of main stem, 42.0cm of secondary branches and 22.80 cm of tertiary branches at 13th leaf stage; after this no further significant increment in shoot length had been observed. The elongation rate of the plant was the same throughout the life. Length of internodes was very small at first but elongate at successive leaf stages. Up to 2nd leaf stage internodes elongate not > 2.00 cm while after 2nd leaf stage internodes grows at max. length of 4.8 cm, but suddenly internodes became < 0.8 cm at 12th and 13th leaf stages. Shoot wings were more pronounced after 8th leaf stage and almost flat or became foliaceous and photosynthetic. Branching raised after 6th leaf stage, the 1st secondary branch arise from 1st prophyll, second from 2nd prophyll and 3rd and 4th from 1st and second leaves respectively; tertiary branches also raised after 7th leaf stage simultaneously from respective axis of secondary branches.

The biosynthetic product i.e. fresh weight of leaf less shoot at maturity was 2.74gm while dry weight of leafless shoot at maturity was 0.57gm which is 20.80% of total fresh weight. Similarly fresh weight of leaves was 3.85 gm and dry weight of leaves was 0.54 gm which is 14.66% of fresh weight of leaves. Total leaf area measured 358.05 cm^2, no defoliation occurred during whole growing season and leaves dried at time of seed setting. The overall vegetative growth occurred throughout the growing season and suddenly limits at starting of reproductive growth.

Fruits and seeds growth: After 12th or 13th leaf stage small yellow-white, solitary, pedicelled flower buds arisen from the axile of each node of main stem, secondary and tertiary stem. Many of the flower buds bloom in the month of December-January but only some set average 6-7 pods per plant (fruits), and Dry weight of the total pods per plant was obtained 1.65 gm. The mean number of seeds per pod was 3.40 and per plant was 17.80 (showing incomplete maturation of some of the fertilized pods) and lastly the total yield per plant was 1.44 gm (about 129.75% of the total dry weight of the vegetative growth).

Final sum of the work, morphological and statistical observations are quite specific for *Lathyrus sativus* (grass pea) and distinct from other species of the genus which is further useful for more elaborated and comparative studies of the genus *Lathyrus* L.

Pollen Morphology: According to Cheema & Paramjeet (2018) the pollen grain characteristics using LM techniques, collected from flowers in January–March season (accession number-32028, 32029) are as follows-average size 31.66(µm) × 20.00(µm), Sub oblate in shape, aperture 3-Zonocolporate, Psilate ornamentation around exine and 2.02 (µm) exine wall thickness.

Anatomical Features

Root anatomy: The transverse sections of adult roots of *L. sativus* consist primary structures such as the epidermis, cortex and the vascular cylinder sectored into xylem and phloem. The epidermis is the uniseriate outermost layer of the root that lack cuticles and stomata. The cortex comprises multiple layers of irregularly shaped, thin-walled cells with intercellular spaces. Xylem rays comprise 1-3 radial rows of parenchymatous cells that are variable in length and width. Xylem elements are found occupying the root center. In adult roots, the vascular cambium develops and produces the secondary xylem on the inside of the cambium ring and the secondary phloem on the outside of the ring. Since they increase in girth due to secondary growth, the epidermal tissue is sloughed off and replaced with a periderm consisting of phellem and phelloderm, both derived from the phellogen, a single-layered secondary meristem. A multiseriate cortex found below the

periderm comprises parenchymatous cells that are different in shape and size. The cortex also contains prismatic crystals of calcium oxalate and multi-layered, thick-walled sclerenchymatous cells, occasionally in the phloem. Vessels are polygonal, rounded, or oval in shape and have thick walls. Rays are uniseriate or multiseriate with 1-10 rows of rectangular or almost square cells (Cildir, 2011).

Stem Anatomy: In the T.S. of the stem, the outline is rhombic, quadrate, or rounded with two wing-like expansions shorter than the stem diameter or nearly equal to it. Two opposite main ribs are distinct whereas the other ribs are less distinct. The ratio between the length of the wing-like expansions and the stem diameter is approximately 0.5 to 1. The epidermis consists of a single layer of tangentially elongated or almost square cells along with the external wall moderately thicker and covered with a thin cuticle. Assimilatory stems possess a few layers of chlorenchyma (photosynthetic tissue) just below the epidermis. The cortex comprises a few layers of slightly elongated parenchymatous cells with or without intercellular spaces. It also consists of 1-3 layers of collenchyma cells within ribs. The vascular tissues are grouped into large and small collateral vascular bundles, joined by interfascicular fibers, and positioned in a ring around the central cylinder. The large vascular bundles are opposite to the ribs. The number of the bundles varies between 6 and 10. In addition to these bundles, there are often two cortical bundles opposite the wings. Also, there are 1-6 vascular bundles per wing. Above the phloem, sclerenchyma fibers occur in groups and are more developed above larger bundles. A large pith is located in the central region of the stem (Cildir, 2011).

Leaf Anatomy Rectangular or polygonal-shaped epidermis cells are found. Uniseriate, isodiametric, or rectangular cells comprise the upper and lower epidermis. Large air spaces exist between the spongy parenchyma cells, whereas the palisade parenchyma often has tiny intercellular spaces. The size and quantity of stomas vary. Sponged tissue is twice as thick as palisade tissue in most animals. Some species' abaxial and adaxial leaf sides are covered in palisade parenchyma tissue. Strong sclerenchyma tissue is above the phloem and xylem (Cildir, 2011).

Leaf epidermal micromorphology It has mostly isodiametric cells with obscurely undulate anticlinal walls. Most of the stomata are opened or partially closed. The leaf epidermal surface of all the species is glabrous or subglabrous. It does not often bear trichomes (Cildir, 2011).

Chromosome and Karyotype:
With 2n = 14 chromosomes, all accessions of *L. sativus* are diploid. Variations in karyotype formula, chromosome length, total haploid complement, arm ratio, and centromeric index were observed. At least one of the metacentric chromosomes had a secondary constriction. Telocentric chromosomes were absent while variable numbers of sub-metacentric and acrocentric chromosomes were observed. These chromosomes differed in their lengthwise positions in the karyotype. The total length of the largest chromosomes did not vary significantly. However, chromosomes with satellites were longer. The total length of the smallest chromosome was variable among the varieties (Barpete et al. 2012).

Thus, the karyotype morphology was similar in almost all accessions of *Lathyrus sativus*. The satellite pair was also the smallest of the complement. There was polymorphism in the number and position of the secondary and other constrictions.

Chemical Composition:
According to Gonçalves Grass pea protein content (25.6-28.4 % in mature seeds and 17% in mature leaves), is higher than field pea (*P. sativum*) or faba bean (*Vicia faba*), but lower than soybean (*Glycine max*). Grass pea proteins, mainly composed of globulins, albumins, and glutelin, are rich in amino acids such as Aspartic acid and glutamic acid percentages were higher than those of the other amino acids. A.E. Al-Snafi studied the comparison of common amino acid (mg/16g) of *Lathyrus sativus* protein were: aspartic acid 8.53- 27.6, glutamic acid 13.40- 39.5, alanine 3.19- 9.82, arginine 3.29- 21.4, cystine 0- 4.50, glycine 3.45- 9.70, histidine 2.22- 6.61, isoleucine 3.41- 9.77, leucine 5.69- 15.9, lysine 4.08- 16.7, methionine 0.24- 0.82, phenylalanine 2.95-10.6, proline 3.07-9.50, serine 0-10.9, threonine 2.59- 8.43, tyrosine 1.44- 6.07, and Valine3.91- 12.2. The analysis of the composition of four samples of grass pea seeds showed that the plant seeds contained water 7.5-8.2%, starch 48.0-52.3%, acid detergent fiber 4.3-7.3%, ash 2.9-4.6%, fat 0.58- 0.8%, calcium 0.07-0.12 mg/kg, phosphorus 0.37-0.49 mg/kg. Grass pea seeds have the potential to supply enough Crude Protein and amino acid requirements for monogastric animals. A.E. Al-Snafi also mentioned leaf contained -moisture 84.2%, crude protein 6.1%, fat (ether extraction) 1.0%, carbohydrates 7.6%, ash 1.1%, calcium 0.16%,

phosphorus 0.1%, iron 7.3 mg/100g, and carotene (as vitamin A), 6,000 IU/100g. Analysis of green grass peas at the flowering stage on a dry weight basis revealed: protein: 17.3%, fiber: 36.6%, fat: 4.47%, ash: 6.0%, P_2O_5: 0.51%, and CaO: 1.08%.

Traditional uses

The seeds oil was used medicinally to cure scabies, eczema and allergy. Immature pods were cooked and eaten as a vegetable, boiled, salted, and consumed as a snack. Young vegetative parts are cooked as green vegetables and dried for off-season use as a vegetable in Asia. In India, the whole seeds were sometimes boiled but were most often processed into dhal. The flour, made by grinding the whole or split seeds, was sold as (besan). Grass pea was sometimes used to adulterate more expensive pulses, such as chickpeas or pigeon peas. In Bangladesh, roti made of grass pea flour was a staple for landless labourers. In Ethiopia and Eritrea, grass pea seeds were mainly consumed in the form of sauces (wot), shirowot (sauce made of flour), and kikwot (sauce made of hulled split seeds) and were eaten together with injera (a pancake-like unleavened bread). Boiled grass pea seeds (nifro) were also consumed in most areas, whereas kitta (an unleavened bread) made from grass pea seeds was consumed mainly during times of acute food shortage. Young grass pea plants are used as fodder for cattle or for grazing in many countries. As fodder, the plants can be eaten green or as hay (Campbell CJ, 1997; Duke JA, 1981; Ahsan et al, 2010; Teklehaimanot et al, 1993; Kay D, 1979; Al-Snafi AE., 2019).

It was concluded from the study that khesari supported growth performance in pullets either similar to or better than the control birds at the levels tested and that it is well tolerable for layers up to 150 g/kg dietary level without experiencing any remarkable deleterious effects. Khesari did not show any symptoms typical to lathyrism in both grower and layer birds at the levels tested (Chaudhary *et.al.,* 2005).

Statistical observation:

It included 3 tables (Table 1, 2 & 3) containing all the statistical parameters taken in methodology with their range value, mean, and standard error.

Table 1: The plant leaf stages, age (in days) and Root length, Shoot length and Root shoot length ratio (with their range value, mean and standard error)

Plant leaf stage	**Age of Plant (days)**	**Root length (cm) Range Mean±SE**	**Shoot length (cm) Range Mean±SE**	**Root shoot length ratio Range Mean±SE**
Cotyledon stage	4	1.30-1.70 1.5±0.04	0.25-0.35 0.30±0.02	4.90-5.20 5.03±0.08
1st prophyll	6	1.80-2.10 2.0±0.06	0.80-1.20 1.0±0.08	1.80-2.30 2.03±0.14
2nd prophyll	7	2.70-3.00 2.8±0.06	2.40-2.60 2.50±0.04	1.10-1.15 1.12±0.14
1st leaf stage	8	3.20-3.70 3.5±0.08	3.00-3.40 3.20±0.07	1.07-1.08 1.07±0.00
2nd leaf stage	8	4.50-4.90 4.7±0.07	6.80-7.50 6.90±0.15	0.65-0.68 0.66±0.01
3rd leaf stage	15	5.50-6.00 5.9±0.09	10.00-12.00 10.90±0.40	0.49-0.55 0.51±0.02
4th leaf stage	16	6.50-7.50 7.0±0.17	14.50-15.60 15.0±0.19	0.45-0.48 0.46±0.00
5th leaf stage	18	9.50-10.80 10.00±0.25	16.00-17.20 16.80±0.21	0.60-0.61 0.60±0.00
6th leaf stage	19	11.20-12.50 11.80±0.22	18.50-19.50 19.00±0.18	0.59-0.62 0.60±0.00
7th leaf stage	21	13.50-14.80 14.10±0.23	22.00-23.50 22.90±0.26	0.60-0.62 0.61±0.00
8th leaf stage	29	17.60-18.20 18.00±0.10	23.80-24.10 23.90±0.05	0.72-0.75 0.74±0.10
9th leaf stage	34	19.80-21.00 20.40±0.23	28.00-29.00 28.50±0.16	0.68-0.71 0.69±0.00
10th and 11th leaf stage	54	28.00-29.50 28.70±0.25	35.00-37.00 36.10±0.33	0.70-0.71 0.70±0.00
12th and 13th leaf stage	57	30.00-31.00 30.60±0.18	38.00-40.10 39.10±0.40	0.69-0.74 0.71±0.14

Table 2: Length of internodes, secondary and tertiary branches (with their range value, mean and standard error), number of secondary and tertiary branches at different leaf stage.

Internodes stage	Length of Internodes (cm) Range Mean ±SE	Number of 2^0/ 3^0branches	Length of 2^0/ 3^0 branches (cm)	
			Range Mean ±SE	Range Mean ±SE
1st prophyll internode	0.60-0.80 0.72±0.03	-/-	-	-
2nd prophyll internode	0.70-0.90 0.78±0.03	-/-	-	-
1st leaf internode	1.40-1.60 1.50±0.03	-/-	-	-
2nd leaf internode	1.70-1.90 1.81±0.04	-/-	-	-
3rd leaf internode	2.30-2.55 2.44±0.04	-/-	-	-
4th leaf internode	2.25-2.40 2.34±0.02	-/-	-	-
5th leaf internode	2.90-3.10 3.02±0.03	-/-	-	-
6th leaf internode	3.40-3.60 3.52±0.03	-/-	-	-
7th leaf internode	3.90-4.10 4.00±0.04	1/-	10.50-12.00 11.70±0.28	-
8th leaf internode	3.80-4.20 4.00±0.08	1/1	17.00-20.00 18.00±0.50	5.00-6.00 6.70±0.16
9th leaf internode	4.60-5.00 4.80±0.07	3/2	26.00-28.50 27.00±0.43	6.00-7.50 6.70±0.25
10th leaf internode	4.60-5.00 4.80±0.07	3/2	36.00-38.00 37.00±0.50	9.50-11.00 10.10±0.29
11th leaf internode	2.80-3.20 3.00±0.07	3/2	36.00-39.00 38.00±0.50	17.50-19.00 18.10±0.40
12th leaf internode	0.60-1.00 0.80±0.08	3/3	38.00-40.50 39.10±0.40	18.00-20.00 19.00±0.31
13th leaf internode	0.04-0.60 0.50±0.04	4/3	41.00-44.00 42.00±0.58	22.00-23.00 22.80±0.24

Table 3: The vegetative and reproductive growth parameters after plant maturity (with their range value, mean and standard error)

Parameters	Range	Mean ± SE
Fresh weight of leafless shoot/plant (gm)	2.41-2.90	2.74±0.10
Dry weight of leafless shoot/plant (gm)	0.50-0.66	0.57±0.02
Fresh weight of leaves /plant (gm)	3.10-4.33	3.85±0.21
Dry weight of leaves /plant(gm)	0.48-0.60	0.54±0.02
Total number of leaves/plant	41.00-53.00	48.80±2.1
Total leaf area/plant (cm^2)	299.90-401.88	358.05±17.13
Total number of pods/plant	5.00-9.00	6.80±0.13
Dry weight of total pods/plant (gm)	1.22-1.90	1.65±0.14
Total number of seeds/plant	12.00-23.00	17.88±2.
Total number of seeds/pod	1.00-5.00	3.40±0.24
Total yield/plant	0.95-1.62	1.44±0.15
Specific weight of seed (100 seeds)	$\frac{\text{Weight of 100 seeds}}{100} = \frac{8.858}{100} = 0.0858$gm	

Table 4: Proximate composition of khesari -*L. sativus* (Sharma A. *et.al.*)

S. No.	Parameters(%)	Raw seeds	Soaked seeds	Autoclaved seeds
1	Moisture	11.64	13.21	12.75
2	Protein	26.25	23.32	18.95
3	Ash	3.39	2.88	1.87
4	Ether extract	1.86	2.03	0.03
5	Fibre	7.23	7.08	6.79
6	Nitrogen free extract	49.63	53.68	60.32
7	Energy(Kcal)	319.00	323.00	327.00
8	Total soluble sugar	4.34	4.12	3.17

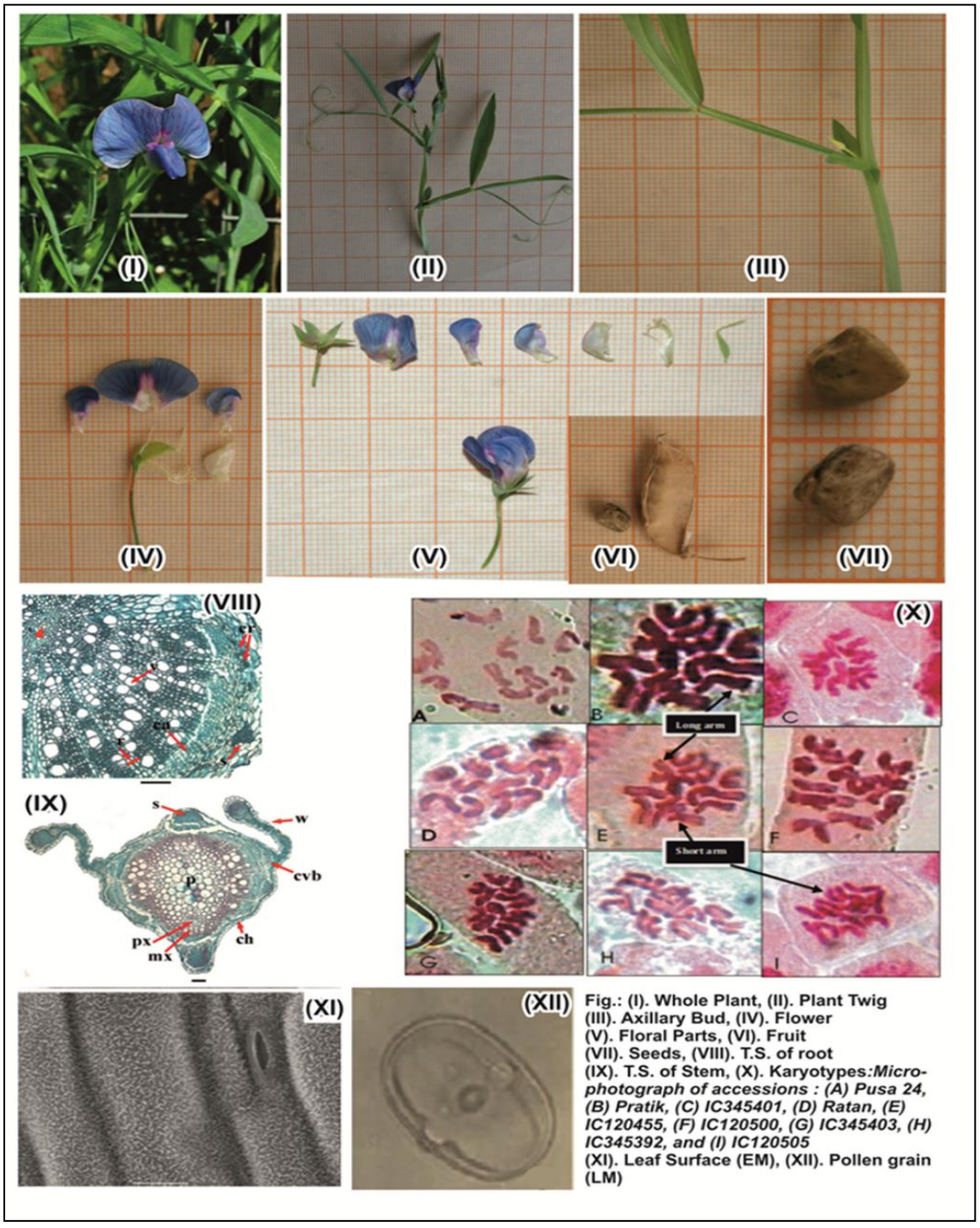

Fig.: (I). Whole Plant, (II). Plant Twig
(III). Axillary Bud, (IV). Flower
(V). Floral Parts, (VI). Fruit
(VII). Seeds, (VIII). T.S. of root
(IX). T.S. of Stem, (X). Karyotypes:*Micro-photograph of accessions : (A) Pusa 24, (B) Pratik, (C) IC345401, (D) Ratan, (E) IC120455, (F) IC120500, (G) IC345403, (H) IC345392, and (I) IC120505*
(XI). Leaf Surface (EM), (XII). Pollen grain (LM)

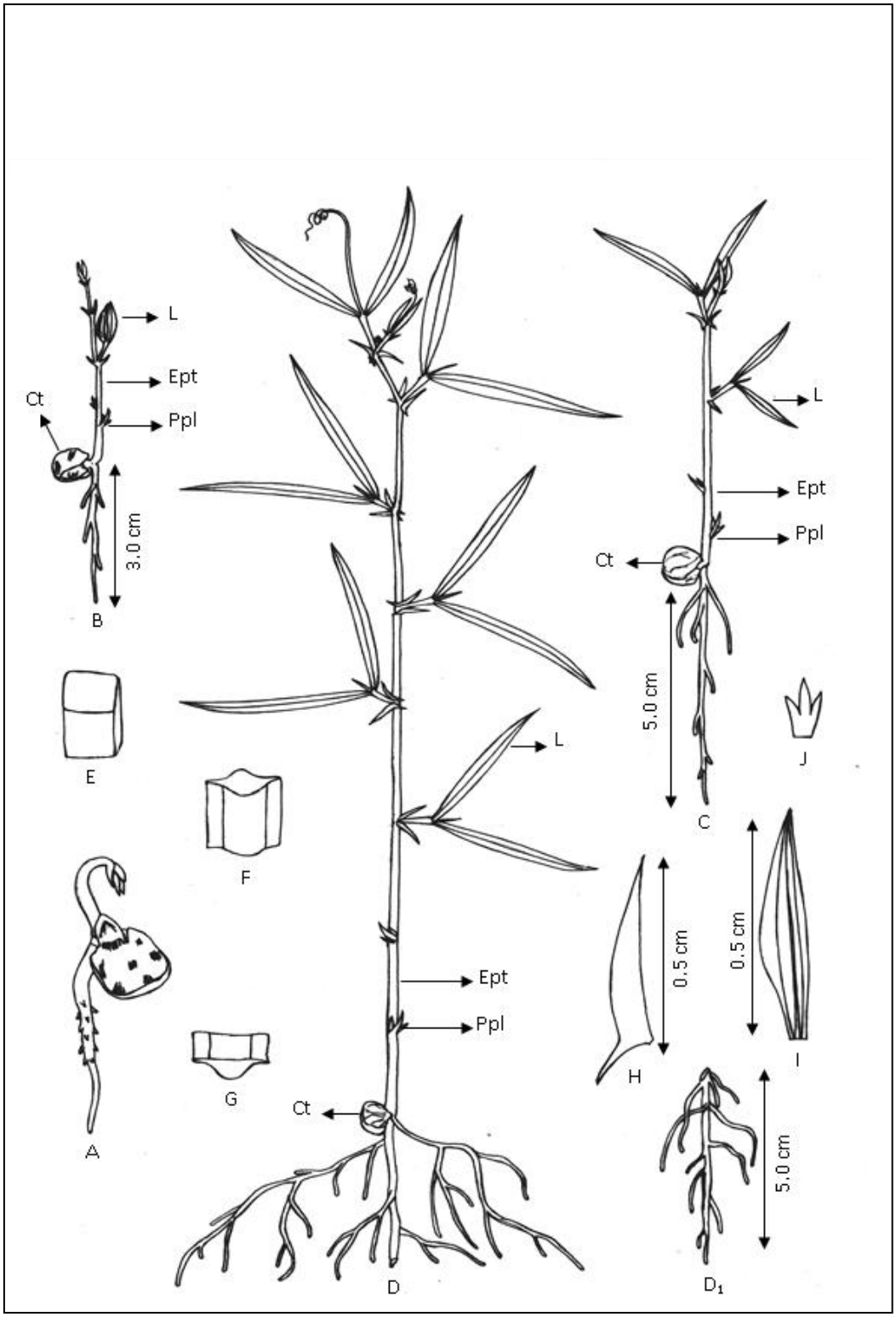

Fig.: *Lathyrus sativus* : A. Early germination, B.Second leaf stage, C. Third leaf stage, D. Seventh leaf stage, D_1. Part of root, E. Part of epicotyl at prophyll stage, F. Part of epicotyl after 2nd leaf stage, G. Part of petiole, H. Stipule, I. Single leaflet, J. Prophyll, Ept. Epicotyl, Ct. Cotyledon, L. First leaf, Ppl. Prophyll.

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