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OCCURRENCE AND DIVERSITY OF *CICER MICROPHYLLUM* BENTH. IN THE TRANS-HIMALAYAN COLD DESERT OF SPITI AND LAHAUL

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Wild species of genus Cicer *are of considerable importance as they possess useful genes for morpho-agronomic attributes, quality traits, adaptation and also confer resistance to biotic/abiotic stresses.* C. microphyllum *is the only wild species of* Cicer *that occurs in the cold arid desert of Trans-Himalayan region. Germplasm collections of this species were made in the past and studies showed its usefulness and importance in the chickpea breeding/improvement programme. Ample scope exists for its utilization using biotechnology and molecular biology. A case for establishing a genetic reserve in Lari hills, Spiti Valley has been proposed to conserve biodiversity of this valuable species.*

The survey and collection of wild *Cicer* species from their natural habitats has been emphasized to widen the genepool diversity (Vander Maesen, 1973). Paradoxically, due to ignorance or unconscious neglect, such resources have been lost or brought to the brink of extinction without getting an opportunity for detailed investigations. Often live plants become so rare that it is difficult to collect the seeds and live material from natural habitats. However, based on the herbarium specimens and well documented passport data, it is much easier for plant explorers to re-locate material of such wild species and this is true in case of *Cicer microphyllum* Benth. Comprehensive exploration strategy for capturing adequate germplasm diversity in India and adjacent region of Afghanistan has been considered very useful. Adequate genepool resources of the wild *Cicer* species are of immense value to chickpea breeders.

In Indian gene centre, apart from rich genetic diversity in cultivated species (*C. arietinum*), two wild species *C. songaricum* Steph. and *C. microphyllum* Benth. are enumerated in Indian Floras and Botanical accounts. *C. songaricum* Steph., a commonly cultivated species is listed in the Flora of India (Hooker, 1879) and also dealt in Flora of Ladakh, Western Tibet (Stewart, 1916-17). However, it appears that some taxonomic and nomenclatural confusion exists. *C. songaricum* Steph., ex. DC mentioned in the Indian Floras is really *C. microphyllum* Benth., the real *C. songaricum* Steph. is a native of Kazakistan, Kirghizia and Tadzkistan of the erstwhile Soviet Russia (Vander Maesen, personal communication). According to recent taxonomic treatment. *C. microphyllum* is grouped under section III, *Polycicer* (non-spiny perennials) and is reported to be distributed in Himalaya, East Afghanistan, West Tibet, Pamir mountains (3000-5600 ft.) and generally comes under vegetation during June-August (Vander Maesen, 1972). This species was first collected from Lahaul Valley, opposite Keylong across the river and later from Zanscar Valley of Ladakh Himalaya. Interestingly in an extensive exploration trip undertaken in Spiit region of cold Himalayan desert (Fig. 1), the occurrence of *Cicer microphyllum* was recorded from Pin Valley, Lari hills, Tabo hills, Poh, Getta Tashigang hills and sporadically along the route from Lossar to Khoksar.

Occurrence of *C. microphyllum* Benth.

Lahaul and Spiti region lies in the east of Lahaul and Kullu at the extreme north-eastern portion of Himachal Pradesh between 31° 42'N and 33° and 76°E and 77° 75'E longitude. Trans-Himalayan cold desert lies adjoining Tibet at mean elevation of about 4,485 m above sea level. Spiti region constitutes a typical mountain desert with an annual precipitation of about 177 mm possessing bare rocky mountains from bottom to top except for a few locations. The topography is very rugged. Vegetation cover of the entire Spiti region is very sparse, yet due to dry climate, it is most varied and attractive. The ground vegetation, though usually sparse in Spiti valley yet in Bhar and Tud regions consisting of high altitude alpine regions (Gette hills, Lalung hills, Pin Valley etc.), rich vegetation cover is found. Amazing array of wild species such as *Agropyron, Medicago falcata, M. minima, Linum perenne, Bunium persicum, Carum bulbocastanum, Avena, Astragalus, Vicia, Cymbopogon jwarancusa,*

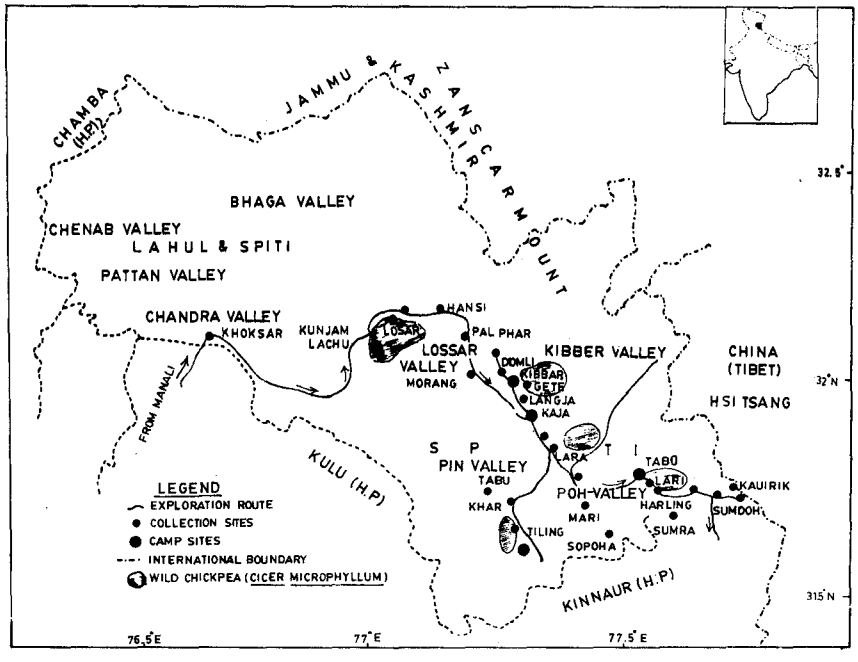

Fig. 1 : Distribution of *Cicer microphyllum* and sites of collection in Spiti Himalayas

Hyssopus officinale, Fragaria indica etc. occur in diverse locations. *C. microphyllum* is fairly wide spread in Spiti region in well isolated colonies often showing disjunct distribution. The occurrence of *C. microphyllum* was observed at several sites down the Rohtang pass on way to Kaza. However, in these sites only sporadic occurrence, much sparse and smaller plant populations occur. Interestingly at Lari hills extensive populations occur in the steep mountainous slopes facing westwards. These sites were explored in 1982, 1985 and in 1992 and fairly large population samples were collected. Earlier, this wild species was also located at Chhota Dara, Lossar, Poh, Gettle-Tashigang hills, Lari hills, Tabo hills and from Pin valley opposite Tangti hills. Samples comprised pods, herbarium specimens and photographs. Lari hills slopes are very steep, stony

with loose soil and generally being devoid of surface moisture. In this natural habitat, perennial, luxuriant tufted bushes occur ranging from 0.5-0.8m in diameter; the plant populations are evenly distributed over an area covering almost one km long mountainous range. Plants are found to grow well on a range of well drained soils, usually allowing its thick long perennial tap roots to penetrate deep down the hilly soils to survive on receding moisture after glaciers have melted down. The soil pH generally ranged between 7.0-7.5 and species preferred open hill slopes exposed to intense sunlight. Flowering and fruiting commences early in light dry soils (Lari hills) than a slightly heavy soils (Gette hills) and on slopes exposed to intense solar radiation. At Lari, Tabo and Poh hills, high seed setting was observed, while at Gette hills, although flowering and fruiting appeared to be normal yet most of the pods were either empty or had low seed setting.

In Lahaul–Spiti regions, both high moutainous and valleys receive a heavy snowfall and most of the area remains covered with deep snow several meters until mid April/May, when snow starts melting on hill slopes due to intense solar heat. At this stage, seeds which have remained burried under deep snow under ultra freezing temperature (–20° to –35°C) and have received sufficient freezing treatment, start germinating. Besides, the deep, woody tap roots of the previous stands remain embedded in the rocky slopes. The dormant shoots under deep snow, start sprouting only at the fall of spring. Similar observations were made by vander Maesen (1979). According to him perennial *Cicer* species grow at higher altitudes (900-1800m) in rubble slopes, under dry conditions with reasonable humidity. They are subjected to severe cold in winter and aerial parts die off. The following spring, woody tap roots often penetrating deep into the crevices give rise to new shoots. Normally in Spiti region during this period, days are fairly long, while temperature is low initially. In general, long days induce early flowering and short days delay flowering. During the flowering period (July-August), the average minimum and maximum temperatures are 10-18°C and 20-35°C respectively depending upon the altitudes, location and sunshine. Under such ecological sites, wild *Cicer* grows well during the dry spring-summer season (May-August) and generally survives on residual moisture. The fruiting was observed to be exceptionally high at several locations, yet ripening was slightly delayed in Pin

valley as well as Gette-Tashigang hills. The details of collections are given Table 1.

Table 1 : Collection of wild *C. microphyllum* in Spiti Himalayas

Collector's number	National collection No.	Place/site of collection	Altitude (m)
C-457	NC 60734	Lari hills	3300-4200
C-520	NC 60735	Gette hills	4350-4500
C-556	NC 60736	Pin Valley (Tangti hills)	3750-4200
C-501	NC 60737	Lossar hills	4050-4200

Taxonomical description

C. microphyllum Benth., unlike the cultivated chickpea (*C. arietinum* L.) is truly wild, perennial species, usually erect or procumbent in habit, often tufted due to excessive grazing by wild blue sheeps. Stem, thin woody, wiry, sub-glabarous about 30-40 cm. in height. Branches, 4-10; leaves, 7.5-9.0 cm. long, alternate, imparipinnate; leaflets, 6.8 × 0.5 cm., in 10-12 pairs growing gradually smaller upward, strongly veined, serrate margins; bracts prominent; inflorescence, axillary raceme, pedicellate; pedicel 5.0-6.0 cm long. Flower, purplish; calyx, green, 5, gamosepalous, persistent; corolla, light blue or purplish, petals, 5, gamopetalous, 1.5-2.0 cm long; stamens 10 (9+1), diadelphous condition; anthers yellow. Pods usually one, occasionally two, 2.5-3.5 cm long, linear, oblong, slightly curved, cuneate, densely pubescent; hairs fine, whitish; seeds, usually 4-6, small, brownish black, mottled and mature during August depending upon the site, slopes and its location. Profuse fruiting occurs in the natural habitats and pod shattering is usually very violent with spiral twisting of pod valves. This process confirms the presence of strong parchment layer, which in naturally occurring wild species, enables the seeds to disperse far apart. Coiling of pod valves helps to retain one or two seeds within the coil that ensures safe seed dispersal beneath the bushes thus allowing potential natural mechanism for survival, perpetuation and evolution.

Genetic diversity

Variations occur for plant type in different agroecological and microniches. Pod size and number of seeds per pod also vary considerably. The pod size range from 2.5 to 3.5 cm, while number of seeds per pod varied from 4-6 (Fig. 2). Inter and intra-population variations also occur presumably due to spatial and temporal differences. Isolation and local environmental factors also contribute significantly. Young unripe seeds of *C. microphyllum* are usually collected by tribal inhabitants for consumption. The lush green foliage, a bit sticky and with mild saltish taste is relished by wild blue sheep as well as domesticated goats and sheep. These animals easily climb the tenaceous alpine slopes for grazing. Plants are also cut at ground level during August-September and are sun-dried as hay for cattle feed. The detailed analytical studies (Chandel *et al.*, 1987) showed that seeds and herbage both are fairly nutritious. In *C. microphyllum*, crude protein varied from 9.27 to 13.30 per cent in forage (Table 2), while it ranged in seeds from 24.1 to 25.6 per cent. The seed protein content of the two accessions analysed were relatively high. N.C. 60734 contained 25.6 per cent crude protein while N.C. 60734 possessed 24.1 per cent (Table 2).

Table 2 : Chemical constituents of *C. microphyllum*

Accession number	Material	Crude protein (%)	Acid detergent fibre (%)	Neutral detergent fibre (%)	*In vitro*-dry matter digestibility (%)	Calcium (%)	Phosphorus (%)
C-967	Dried	9.27	36.40	47.20	69.79	3.50	0.43
C-1067	leaves	13.30	40.20	54.00	65.44	2.40	0.23

The nutrient status of wild chickpea compares well with that of the cultivated species. The leaves are also rich in protein and carbohydrate and appears to have good potential as forage species in cold desert regions of Himalayas (Chandel, 1992).

Utilization prospects

The wild *Cicer* species can play an important role in the improvement of chickpea. Interspecific hybridization could be of particular importance, which assumes much greater significance today with the emergence of new techniques of biotechnology and

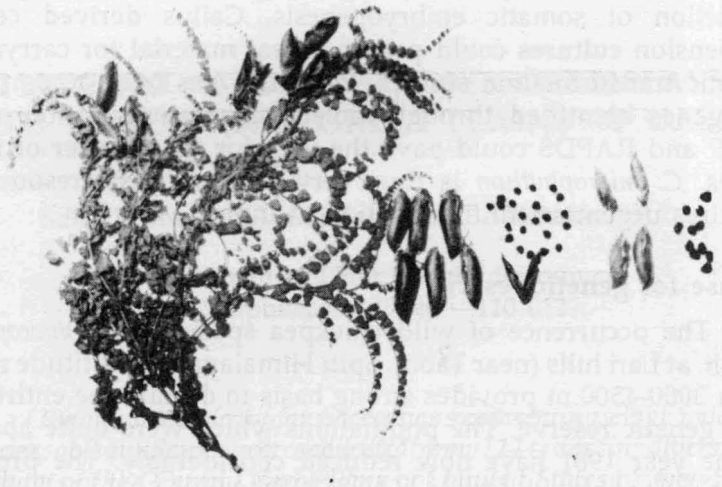

Fig. 2 : Plant type in *Cicer microphyllum;* Pods and seeds separately shown

genetic engineering. Embryo rescue, somaclonal variation, protoplast fusion (somatic hybridization) and recombinant DNA technology can be profitably integrated with conventional chickpea breeding programme. *C. microphyllum* could be of special interest in breeding, as it appears to possess high tolerance to drought and cold (frost). The genes available for long poddedness and high number of seeds per pod, could enhance productivity of chickpea cultivars. The screening for resistance for pod weevil and bruchids could be of interest in chickpea breeding. Vander Maesen (1973) reported that *C. microphyllum* and *C. pinnatifidum* have beer. used for hybridization in India, Pakistan and Israel. It is also indicated that there is lack of information on disease resistance in most of wild species of *Cicer*. Yet, high degree of drought tolerance and cold hardiness found in *C. microphyllum* could be profitably utilized. Hence, genetic resources of this wild species offer good prospects in chickpea improvement. The seed dormancy developed during the course of long evolutionary history of this wild species require intensive physiological and biochemical investigations to enable its full utilization. Seeds require breaking of dormancy which imposes hard seededness and non germinability. This could be overcome by seed scarification and stratification at low temperature (0-4°C) for atleast 30-60 days. Both partially and fully mature seeds and embryos can be used for *in vitro* studies. The regeneration could

be achieved directly or through organognesis leading to the induction of somatic embryogenesis. Callus derived cell and suspension cultures could provide ideal material for carrying out genetic transformation studies. Once this has been accomplished, the genes identified through molecular characterization such as RFLP and RAPDS could pave the way for the transfer of nuclear genes. *C. microphyllum* is thus very precious gene resource and requires urgent scientific attention in India.

A case for genetic reserve

The occurrence of wild chickpea species *Cicer microphyllum* Benth. at Lari hills (near Tabo), Spiti Himalaya at an altitude ranging from 3000-4500 m provides strong basis to declare the entire range as a genetic reserve. The populations which were quite abundant in the year 1981 have now reduced considerably. The protective measures are required not only to halt the genetic erosion in the wild occurring populations but also to allow the process of evolution to continue unaltered. Lari hills perhaps provides the unique microniches for this potential wild species likely to be of considerable importance in the future. Thus, it requires adequate measures for its protection. Department of Environment in collaboration with Himachal Pradesh of can jointly work out the plan for making Lari hills as the genetic reserve for *C. microphyllum*. This will lead toward successful implementation of biodiversity conservation programme.

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