

GM crops and centres of origin – a case study of *Bt* brinjal in India

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Brinjal (eggplant, aubergine, *Solanum melongena* L.) commands an important place in the world and Indian vegetable production. In the backdrop of the recent moratorium on the commercialization of *Bt* brinjal in India, the issue of the probable centre of origin of brinjal has assumed a greater significance. Brinjal is the vegetable of the Old World. Opponents of the commercialization of *Bt* brinjal have argued that its introduction into Indian agriculture might threaten the genetic diversity of wild and cultivated forms of brinjal by extensive adoption of *Bt* brinjal and cause 'genetic erosion' by horizontal spread of *Bt* transgenes into wild and weedy relatives of brinjal. They have also argued that *Bt* brinjal should not be released in India, which is the centre of origin of brinjal. Most of the Indian literature considers India as the centre of origin of brinjal.

Several arguments have been put forth in favour of the possibility that brinjal is native to India:

(a) Large genetic diversity exists in brinjal germplasm for many morphological and agronomically important traits in India, pointing to the possibility that the country is the centre of origin of brinjal.

(b) Documented historical records, including Ayurveda and other systems of medicine refer to brinjal.

(c) Several candidate areas for brinjal domestication have been proposed: India and South East China¹; China, India and Thailand²; Indo-Burma region³; Burma to Indo-China⁴, and South East Asia⁵.

Unfortunately, there are no strong points of argument about India being the centre of origin of brinjal. Comprehensive and critical analysis of the literature suggests varying indications about the origin, domestication, speciation and evolution of brinjal. The following are some of the pointers that counter the veracity of the belief that India is the centre of origin of brinjal:

(a) Even though diversity exists in the morphological traits of brinjal, there is hardly any proof indicating that most of the accessions of the brinjal germplasm are genetically divergent enough to

account for the documented diversity. The size of the germplasm is not substantially large to account for its origin being India. Claims on the number of brinjal germplasm accessions available in India to the tune of 2000 or more are unsubstantiated. Most of the germplasm accessions include duplicate entries, morphological variants (without substantial genetic diversity), breeding (segregating) stocks (arising from common parental populations or sibs, crosses and based on simple selections), and other uncharacterized replicates. Besides, mere presence of a large morphological diversity need not support the centre of origin. A crop can be introduced into a region and diversity may later be generated due to many forces of adaptation. Vavilov's proposal³ that the centres of diversity are indeed the centres of origin is not tenable in its entirety. Vavilov's concept in a nutshell is: the place of origin of a species of a cultivated plant is to be found in the area which contains the largest number of genetic varieties of this plant. As pointed out by Stebbins⁶, Vavilov's interpretation of diversity patterns is an elaboration on Willis' age-and-area hypothesis, based on oversimplified hypotheses, and therefore Vavilov's concept of centre of origin should be greatly revised⁷.

(b) Vavilov was of the implicit opinion that crop species had each been domesticated only once when he proposed his centres of domestication, and this assumption has been borne out for a number of species, including maize, bread wheat and sunflower. Interestingly, no clear information is available on the numbers of domestication for many crops, including tomato, brinjal and rapeseed^{1,2,8}. Vavilov's centres of origin and domestication are only a valuable first hypothesis as to where crops originated and where our sessile, agrarian cultures began. Since then, great strides have been made scientifically in pinpointing the origins of our domesticated crops and the associated wild species from which the respective cultivated crops have arisen. Our understanding of the details of the centres of origin has substantially metamorphosed over the last eight decades of intensive research. Interestingly and bewilderingly,

there is still no clear consensus on the subject.

(c) Hooker⁹ in *The Flora of British India*, concedes as follows: 'De Candolle says it is a native of Asia and not America, and Sendtner fixes its origin in Arabia; all these appear uncertain.'

(d) Brinjal is a member of Solanaceae, to which closely related crops like potato, tomato and chillies also belong. Genus *Solanum* is predominantly Central and South American, whereas the question of the centre of origin of *S. melongena* is yet to be resolved. Evidence for each of these is based on the presence of weedy forms (putative progenitors for many authors) and literature references. However, there is a possibility of multiple domestication events, which needs to be studied¹⁰. Evolutionary evidences suggest that the progenitor of present-day brinjal, *S. melongena*, is the wild *S. incanum*. The centre of *S. incanum* is not India, but Africa. A logical approach to the problem of centre of origin would be to find out, utilizing the tools of molecular systematics, the wild progenitors of cultivated plants and their geographical distribution. By doing so, *S. incanum*, the progenitor of *S. melongena*, can be traced to African centre of origin and not Indo-Burma region.

(e) Karihaloo and Gottlieb¹¹, through their studies on allozyme and RAPD variation in *S. melongena* and similar wild and weedy forms, suggested that *S. melongena* originated from an African species, *S. incanum*, as supported by AFLP and DNA sequence datasets and also established that even though *S. melongena* and *S. incanum* (another wild relative) are highly morphologically diverse, it is no longer appropriate to distinguish them taxonomically¹².

(f) Mere mention in Ayurveda and other systems of medicine does not qualify the argument that brinjal is an ancient crop that was historically known in India. Evidence for an Indian domestication has been drawn from examination of the Sanskrit literature. Khan¹³ cited common names for the eggplant from various works, with the oldest dated between the 3rd century BC and the 3rd century AD. His citation of the oldest Sanskrit work from 300 BC, however, was based

on a secondary source¹⁴, and the time range he estimated cannot be substantiated, due to the many revisions of the work in question over the centuries¹⁰.

(g) The true wild progenitor of brinjal has even been hypothesized to be an undiscovered species in the Savanna ecosystems of the region⁵. Much of the uncertainty regarding the centre of origin of brinjal and its relationship with other species, including Asian prickly Solanums arise from the fact that most of the researchers have used a small number of collections only from the South Asian region^{11,12,15,16}. Besides, *S. melongena* can be crossed not only to putative progenitors but also to more distantly related species, within the section *Melongena*, with the species of *Oliganthes* and those of other sections. Moreover, due to high morphological variability, morphological data can lead to ambiguous interpretations.

(h) Further, there is also a suggestion that the wild progenitor developed as a garden weed, and through human selection in South East Asia, progressively more advanced cultivars were selected. Consequently, *S. melongena* was divided into a series of morphological types or gene pools, complicating the patterns of character change associated with the movements of cultivars⁵.

(i) Molecular evidences suggest that brinjal may have originated in South America, Africa and Asia¹⁶. Molecular data, including AFLP support the broad relationships between *S. incanum* and its African relatives and the eggplants¹⁷, but the datasets did not include Chinese samples¹⁰. None of the *S. incanum* subspecies group as currently understood is present in China or adjacent South East Asia.

Therefore, it can be clearly inferred that:

(1) India is not the only primary centre of origin of brinjal. There is a possibility of multiple origin and domestication events, which needs to be studied further. It may be considered that India is either a centre of diffuse origin or even only a centre of diversity. Origins are diffuse in both time and space, and consequently the problem of a 'centre of origin' can never quite be solved¹⁸. Lack of archaeological evidence should not attract

conclusions based on hypothetical premises.

(2) Citations from Ayurveda cannot be taken to infer that India is the centre of origin of brinjal. Sanskrit names have been regarded as evidence that the brinjal was first domesticated in India, although no further detailed and continuous evidence about the domestication process can be gleaned from the ancient Indian literature. It is essential that the primary sources of exact dates be re-examined in order to explore this further.

(3) Even though careful measures are needed when cultivating genetically engineered crops near the centres of origin, two things are obvious; first, India is not the centre of origin of brinjal and therefore we need not be conservative; secondly, this situation is not unique to GM crops alone and can happen with non-GM too. Key to judging the impact of transgene movement is the nature of the trait and the frequency of its introduction into the ecosystem¹⁹. Environmental risk assessment and statement is a long-term policy requirement to be judiciously implemented by all GM-growing countries with defined regulatory framework. In India, for any GM crop, including *Bt* brinjal, such an exercise is required and will be in place.

(4) Changes in key morphological and biochemical traits that occur during the process of crop domestication are mostly inferred by reference to wild relatives or to primitive land races, and have long been the subject of debate. Only in the case of genetic analysis of the availability of extensive plant fossil remains can specific sets of changes be documented. Historical details of the plant domestication processes are rare and other evidences of morphological changes can be equally difficult to arrive at, especially for vegetables like brinjal where substantial body of archaeological data is lacking.

An attempt has been made in this paper, for the first time, to scientifically question the veracity of the commonly held belief that India is the centre of origin of brinjal and surprisingly, this belief seems to be untenable.

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