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Genetic Variability and Traditional Practices in Naga King Chili Landraces of Nagaland

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Abstract

Recently Naga King Chili (Bhoot jolokia *or* Naga jolokia *in Assamese*) *was rediscovered by the world scientific communities when it was declared as the hottest chili of the world. Interestingly this particular type of chili with its unique hotness and aroma is native to the northeastern part of India, more particularly to Nagaland. In Nagaland, the crop is cultivated by traditional ways since time immemorial and a good amount of genetic variability exists in the local landraces of the state. However, very little research towards scientific cultivation of this potential crop was accomplished in recent years and until now scientific package of practices is not available for the crop. In the present investigation, local genetic worth, traditional cultivation and processing practices, and traditional uses were focused by extensive field visits and systematic interviews of local farmers of traditional growing areas of Nagaland. There is tremendous scope to utilize these genetic variabilities in planned plant breeding experiments for further development of elite genotypes in this crop. Scientific documentation of the different available landraces of Naga King Chili will be useful in establishing its nativeness in the state.*

In recent years, the traditional crop of Nagaland in Northeast India, the Naga King Chili (*Bhoot jolokia* or *Naga jolokia*) is gaining importance in the scientific community as it was reported to be the hottest chili in the world. Besides Nagaland, the crop is also traditionally cultivated in Assam, Manipur, and other northeastern states of the country. In Assam, this type of chili is popularly known as *Bhoot jolokia* or *Bih jolokia*. These two terms are now popularly found in the present-day scientific literature. The Assamese word "*bhoot*" refers to the typical large pod size of the plant, while the term "*bih*" means "poison" indicating the high hotness in the fruits of the plant. The term "*bhoot jolokia*" could not be translated into English as "ghost chili" as

was explained by many researchers. Because of its great hotness it is also popularly known as *Saga jolokia* (Saga chili), Indian mystery chile, Indian rough chili, etc.

The potentiality of Naga King Chili or *Bhoot jalokia* was first reported from Tezpur district of Assam, in 2000 and the tremendous hotness was analyzed in the Defence Research Laboratory situated in Tezpur. As a result of this declaration of the hotness in terms of Scoville Heat Unit (SHU), the world champion Red Savina Habanero (*Capsicum chinense*) of Mexico was pushed back to the second position. Initially this fact was questioned in the scientific forum and finally following careful scientific procedures to analyze the hotness of Naga King Chili, Dr PW Bosland and his co-workers of New Mexico State University, USA reported a rating of 1,001,304 SHU in 2005. They used a well calibrated High Performance Liquid Chromatograpy (HPLC) method to determine the capsaicinoid level of prepared samples of Naga King Chili. The ppm concentration was later on converted into SHU by multiplying it with a conversion factor of 15 (Bosland, 1996). After this confirmation the million scoville Naga King Chili was certified by Guinness World Records as the hottest chili of the earth in September 2006.

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Botanical facts of Naga King Chili

Chili (*Capsicum* spp.) belongs to the family Solanaceae (Nightshade family) and was evolved from an unknown ancestral form in Peru-Bolivia region of the New World (Heiser, 1976). Heiser (1976) estimated that between 5200 and 3400 BC, chilies were grown by the native Americans of the region and chili was one of the oldest cultivated crops of Americas. Heiser (1976) also stated that Columbus during his famous voyages carried these plants and subsequently introduced into Europe, Asia, and Africa.

There are about twenty-two wild and five cultivated species under the genus *Capsicum*, the cultivated species being *C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens*, and *C. pubescens* (Bosland, 1994). But there are also controversies regarding the individual species status of *annuum*, *chinense*, and *frutescens*. This was questioned by several researchers like McLeod *et al.* (1979, 1983), Pickersgill (1988), and many others and was attributed to the fact that the wild relatives of these three species tend to show taxonomically important similarities. But it is now accepted in the world scientific communities that *Capsicum* species originated in the New

World and therefore nomenclature of *C. chinense* could also be described as a misnomer. This particular species was so named by the Dutch botanist Nikolaus Joseph von Jacquin (1727–1817) as he collected the seeds of these plants from China, thus having a concept that this type of chili might have originated in China (Bosland, 1996).

At the time of the first discovery of tremendous hotness of Naga King Chili in the year 2000, it was reported that *Bhoot jolokia* belongs to *Capsicum frutescens,* but soon controversies were observed for the basis of this classification. Many researchers in this field reported that it is not possible to produce such a record-making hotness by the members of *frutescens* and finally based on morphological characters it was confirmed that Naga King Chili (*Bhoot jolokia*) is a member of *chinense* species (Bosland and Baral, 2007). Based on molecular marker study using random amplified polymorphic DNA (RAPD), Bosland and Baral (2007) also concluded that there is possibility of genetic introgression from *Capsicum frutescens* into Naga King Chili species (*Capsicum chinense*). Thus from the study, it could also be envisaged that Naga King Chili is an interspecific hybrid between the species *chinense* and *frutescens.* It was observed in the present investigation that in Nagaland, specially in the foothills of Dimapur, Mon, Wokha, Peren, and Mukokchung, the wild *frutescens* and *chinense* species are of common occurrence in the forests which indicates the possibility of genetic introgression. Chili is considered as a self-pollinated crop (Allard, 1960). But studies of Odland and Porter (1941), Franceschetti (1971), and Tanksley (1984) revealed that the outcrossing range in chilies is 7 to 91% with the aid of insect pollinators. It was also recorded that meiosis is very regular in interspecific hybrids of the genus *Capsicum* and as a result the interspecific hybrids are highly fertile in nature (Bosland, 1996). These findings also support the easy possibility of genetic introgression into Naga King Chili from *frutescens* species. Comparative taxonomical and molecular marker studies of Naga King Chili, *frutescens* and *chinense* species along with their wild relatives can confirm the species status of Naga King Chilli. Such a study should be conducted in the native place of Naga King Chili like the foothill regions of Nagaland (within 1000 feet above MSL).

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Method of observation

In the present investigation, an effort was made to document the genetic variability, traditional way of cultivation, traditional use, and processing practices of Naga King Chili. Extensive visits were made by the staff of Department of Genetics and Plant Breeding, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema, Dimapur to farmers' fields in the comparatively low altitude areas (within 1000 feet above MSL) of Dimapur and Mon districts of Nagaland in August

2007. During the visits, elderly farmers above 40 years of age were interviewed with the help of a pretested interview schedule to obtain the necessary information on Naga King Chili. Based on the practical field experience and local information, ten distinct germplasms were collected from Dimapur district for further extensive study in the greenhouse and under experimental field conditions. In August and September 2008, village market surveys were also done to record the genetic diversity specially in terms of fruit shape, size, and color. The collected germplasms were critically observed for morphological variations in the traditional growing season (February/March to August/ September) of 2008.

Observations and discussion

Traditional cultivation practices

Farmers stated that traditionally Naga King Chili is cultivated in the *jhum* (shifting cultivation) paddy fields as a sporadic intercrop with summer paddy and also in small homestead gardens. Generally seed is sown in February and March and one- to two-month-old seedlings are transplanted in the main field preferably in a place where bamboo culms have been slashed and burned. Direct seeding is also practiced in *jhum* paddy fields. The usual peak harvesting time of Naga King Chili is in August/September and therefore this is the time when variability of traditional landraces of Naga King Chili in the form of fruit shape, size, and color are found available in the market. Exploration in local village markets at this time may also give much relevant information regarding this crop as most of the local sellers are the actual growers of Naga King Chilies (Fig. 1).

The chili plants intercropped with summer rice are generally not cared after the harvest of the main crop rice as the piece of land might be left fallow and the next year's cultivation of summer paddy may be shifted to some other location. But the homestead chili plants are kept at least for 2 to 3 years beyond which it was reported that the yielding ability and fruit size got reduced to a certain extent. In the homestead gardens, traditional farmers prefer to grow the crop under shade because the performance of the crop is better as compared to very sunny places. In traditional kitchen gardens, Naga King Chili plants grow as high as 12–13 feet at 3 years of age.

Aphid and mealy bug infestations in Naga King Chili are reported to be common in traditional fields. In such infestations, traditionally sieved, very fine wood ash is sprinkled over the plants as well as on the soil near the base of the plants. The most probable scientific explanation of this may be that sprinkling of fine wood ash makes it unfavorable for insect feeding and thus also their reproduction as an immediate effect. On the other hand, as ash contains much potash, it may confer some sort of resistance in the system against such type of infestations (Neog *et al.*, 2004). Moderate to frequent fungal attacks causing immature fruit rot and slow wilting are other problems reported by the traditional farmers of the two study districts. This traditional crop is gaining importance in the state after its rediscovery as the hottest chili in the world

Figure 1. A woman selling Naga King Chili in a local market in Dimapur, Nagaland.

In traditional kitchen gardens, Naga King Chili plants grow as high as 12–13 feet at 3 years of age.

and scientific package of practices for the crop is yet to be developed.

Traditional use and processing practices

The traditional Naga King Chili is a unique gift of nature as its fruits are hottest in the world and at the same time these also possess a pleasant and palatable aroma. Due to these features the chili is popular in Nagaland and other northeastern states. It is consumed as green or fully ripe fruits, either raw or cooked with vegetables (Fig. 2). It is an amazing and interesting fact that a single average-sized fruit is more than sufficient for two meals of the day of a 5- to 6-membered family. Traditionally the fruits are used for curing many human ailments (Table 1).

Generally traditional peak harvesting of Naga King Chili coincides with the later part of monsoon season and therefore farmers usually face problems in drying of chilies

because of rains. It was recorded in the study that farmers prefer to dry the fruits by the traditional way of smoking. Matured fruits are placed in thin layers over bamboo shelves which are purposively made over kitchen fireplaces. This way the fruits could be dried within two to three weeks and during the process, if possible the materials are also exposed to sun to accelerate the process of drying. The main disadvantage of the process is that smoking makes the fruits blackish in color, thus reducing the market value of the fruits. This particular problem could be solved by standardizing the method of electric/solar oven drying of Naga King Chili.

Traditionally the fruits are used for curing many human ailments.

Table 1. Traditional medicinal uses of Naga King Chili in Nagaland.

Traditional medicinal practices	Probable scientific explanations and observations
Patients of asthma get relief by regular use of Naga King Chili. But it should be consumed in low quantities.	The hot principle of Naga King Chili might be responsible for relief from asthma. Clinically it has already been proved that capsaicin has the ability to dilate blood vessels thus giving relief in chronic congestions. The Mayas had also a long tradition of using *Capsicum* to cure asthma, cough, and sore throat (Bosland, 1996).
In case of gastro-intestinal abnormalities, traditionally regular consumption of small quantity of Naga King Chili is practiced. Here also regular consumption, but in small quantity is emphasized.	Capsaicin has the ability to influence the gastro-intestinal activities in a positive way. It stimulates the secretion of saliva and gastric juice (Bosland, 1996). Clinical reports also indicate that capsaicin can protect the mucous membrane of the intestine from mechanical and chemical damage.
Traditionally *Capsicum* spp. (including Naga King Chili) are used to tone up body muscles after heavy work exercises. It is believed that it can keep body pain arising out of heavy work duties at bay. Hot infusions of Naga King Chili fruits are used for toothache and muscle pain. But the infusion should never be applied on injured tissues.	The hot principle of *Capsicum* has the ability to alleviate external pain in muscle (Carmichael, 1991). In case of external application, capsaicin can modulate the amount of specific neurotransmitter (called substance P) associated with the feelings of pain and ultimately can play a positive role in reducing pains (Lynn, 1990).
The tender leaves of Naga King Chili are ground to a fine paste and applied as thin coat over boils. This helps in easy removal of puss from boils.	Naga King Chili leaves might be having medicinal properties but reference to this is rare in literature. Deorani and Sarma (2007) reported the use of chili leaves for ailments such as boils, headache, and night blindness. They also reported that in Nagaland coconut oil is mixed with ground chili leaves and the paste is applied on to boils.

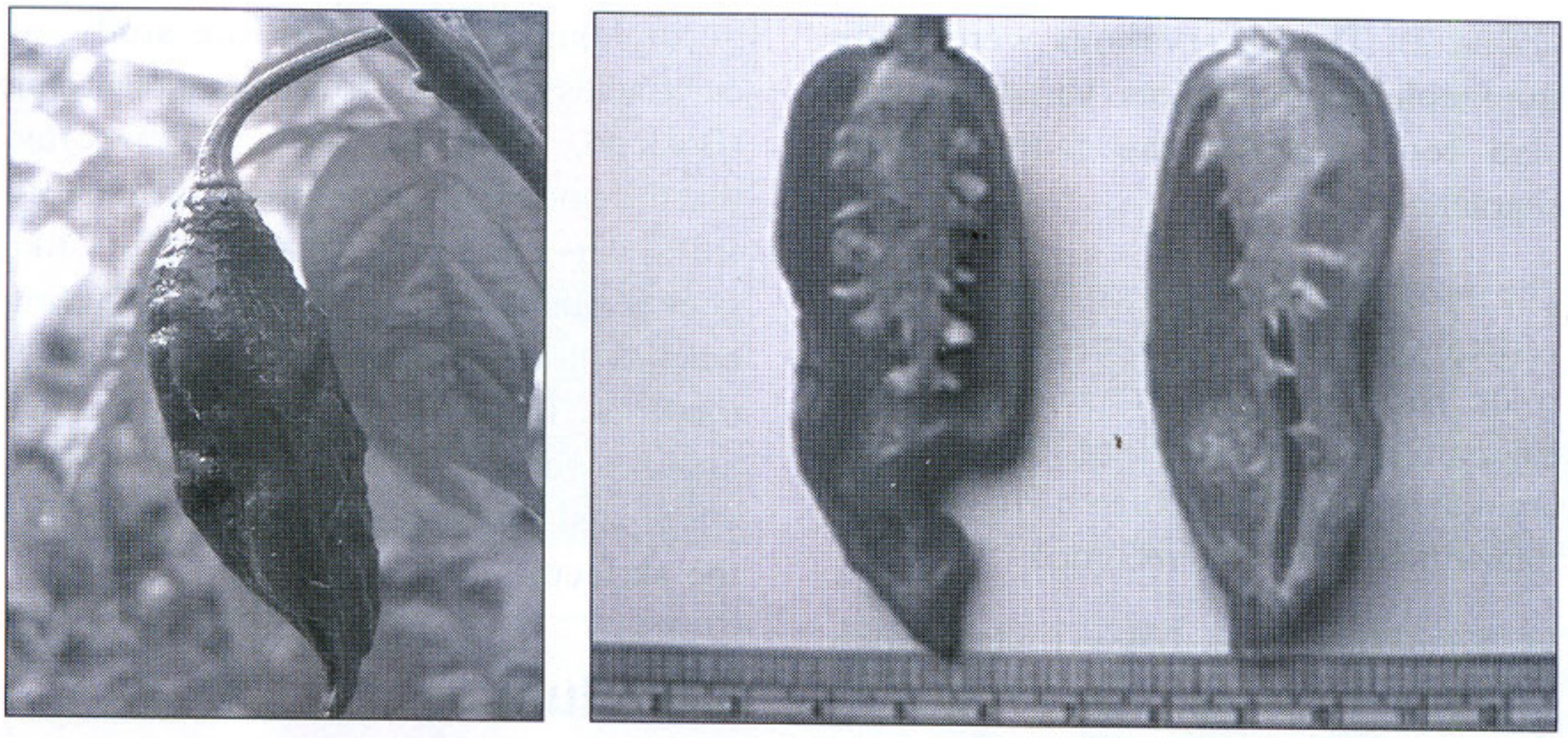

Figure 2. Naga King Chili: (left) mature fruit; (right) longitudinal section of the fruit showing *scanty seeds.*

It was also reported by the farmers that always fully matured fruits should be selected for such traditional drying process. The fruits should be harvested at least one week after they become fully red/orange/ chocolate in color. This helps in preventing the growth of a fungus (which is yet to be identified specially in Naga King Chili), which causes rotting of fruits even during smoking. From repeated observations in different genotypes of Naga King Chili, the fact (preventing fungus) was confirmed during the present investigation.

Traditionally the fruits of Naga King Chili are sliced and made into pickles and preserved easily for months. Three methods are followed to make the pickles:

1. Young bamboo shoots are sliced into fine pieces and ground coarsely. The ground material is then mixed with slices of Naga King Chili fruits and the preparation is exposed to sun for a week or two. Thus the preparation is ready for use and storage. Periodic exposure to sun usually helps in lengthening the shelf life.
2. Mustard oil is heated and then allowed to cool. Slices of Naga King Chili fruits are added to the oil and preserved for future use.
3. The juice from a fully matured lemon is extracted and kept in a container. Slices of Naga King Chili fruits are added to the juice and preserved for future use.

Genetic variability in collected landraces

In the present investigation, the landraces were initially evaluated for a few characters like plant height (at six months of age), number of primary branches, fruits per plant (at six months of age), fruits per node, fruit length, fruit breadth, seeds per fruit, fruit color, node coloration, flower color (before anthesis), and anther color (before anthesis)

(Table 2). The observations were made from replicated field plots. Variations were also recorded for the fruit surface characteristics.

The most interesting and easily observable variation in the germplasms was the fruit color. There are at least three distinct fruit colors in Naga King Chilies like dark red, orange, and dark chocolate (Fig. 3). The following trends were recorded:

- Young light green colored fruits turn into orange at maturity.
- Young dark green colored fruits turn into dark red at maturity.
- Young green colored fruits turn into light red at maturity.
- Young dark green colored fruits turn into chocolate color at maturity.

These trends indicate that there is variation in carotinoid content of fruits of various germplasms collected in the study, as carotinoids govern the fruit coloration in chili (Bosland, 1996). Reeves (1987) reported that the amount of carotinoid present in chili fruits depends upon various factors like genetic make-up of cultivars, prevailing edapho-climatic conditions, and stage of maturity. In our study, the fruit surface characteristics recorded were smooth, warty, and horny (thorn-like structures on the surface).

Conclusion

Naga King Chili with its unique hotness and aroma is native to the northeastern states of India, more particularly to Nagaland as much genetic variabilities in the form of traditional landraces and wild relatives are found in the foothill areas of the state. Some genetic variability could also be easily detected for many economic traits of the crop which actually indicates the possibility

Table 2. Range and classes of a few traits in ten local landraces of Naga King Chili in Nagaland.

Descriptor	Range/phenotypic classes
Plant height (cm) (at 6 months)	57–129
No. of primary branches	7–18
Fruits per plant (up to 6 months)	28–67
Fruit length (cm)	5.1–8.9
Fruit breadth (cm)	2.2–4.2
Fruit weight (g)	5.2–11.5
Fruits per node	1–3
Seeds per fruit	22–47
Fruit color	Orange, red, light red, chocolate
Node color	Absent to deep purple
Flower color (before anthesis)	Greenish white, light brown
Anther color (before anthesis)	Light purple, purple

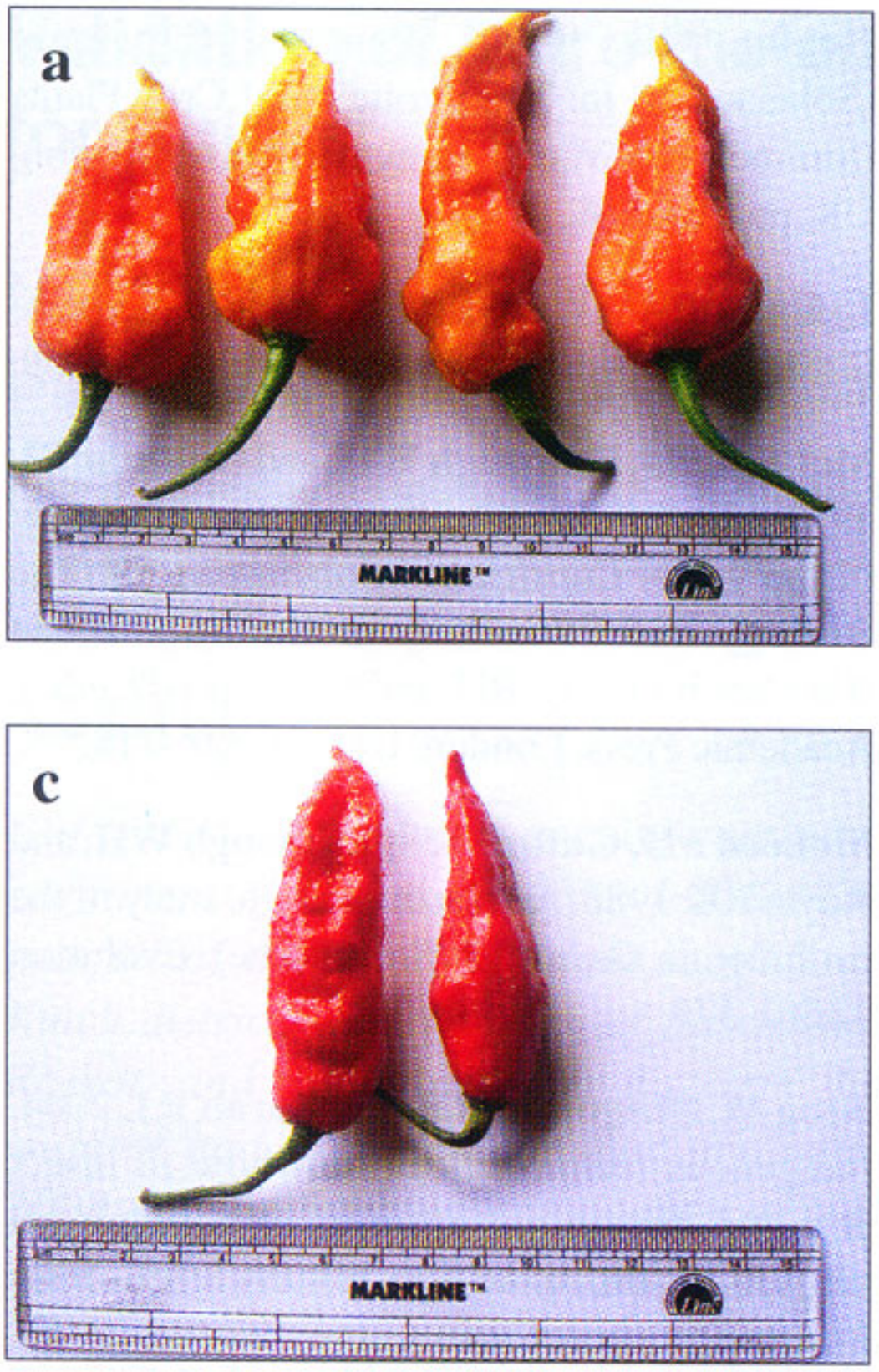

Figure 3. Variability in fruits of Naga King Chili: (a) Orange; (b) Round, red; (c) Red, long, smooth; (d) Chocolate; (e) Red, horny.

of utilizing these existing natural variabilities in planned plant breeding experiments to develop more suitable and elite genotypes. But various cultivation aspects of this traditional crop are still not standardized. Therefore, the scientific community of the state should give judicious attention to this traditional crop for further improvement.

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