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Original Paper

Collaborative Exploration of Cucurbitaceae Vegetable Genetic Resources in Myanmar in 2019

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Summary

This study describes the exploration of genetic resources of cucurbitaceous vegetables in northwestern Myanmar, Sagaing region, and this study was jointly conducted by the National Agriculture and Food Research Organization (NARO), Japan, and the Department of Agriculture Research, Myanmar. A field survey was conducted in northwestern Myanmar from November 1 to 17, 2019. We collected a total of 24 accessions, 16 from *Cucumis sativus* L., two from *Cucumis melo* L., three from *Cucurbita moschata* Duchense, one from *Cucurbita maxima* Duchense ex Lam., one from *Luffa acutangula* (L.) Roxb., and one from *Momordica charantia* L. The collected accessions were stored as seeds at the Myanmar Seed Bank and subsets were transferred to the Genetic Resources Center, NARO, using a standard material transfer agreement.

KEY WORDS: Myanmar, genetic resources, cucumber, pumpkin, melon

Introduction

Myanmar is a large country, ranging from the southern coastal area to the northwestern mountainous area. The Sagaing region is located in the northwestern part of Myanmar and is bordered by India's Nagaland state. These hilly and mountainous areas are inhabited by ethnic groups, mainly several Naga tribes, who perform traditional agricultural practices and grow diverse traditional crops. They cultivate these varieties in slash-and-burn cultivation fields, home gardens, and terrace cultivation fields. The practice of the collection of novel plant genetic resources, which has been passed down within these ethnic groups, is crucial for the development of new varieties that harbor desirable traits, such as disease and pest resistance, improved fruit quality, and higher yields.

This area is of great importance considering the diversity of cucurbitaceous plants. In particular, cucumber is considered to have originated around the southern Himalayan region and introduced to other parts of the world (de Candolle 1886; Bisht *et al.* 2004). Thus, Myanmar is believed to be a promising source of genetic variability for cucurbits (Saito *et al.* 2006; Kawase *et al.* 2011; Yamamoto *et al*. 2011; Domon *et al.* 2015; Naito *et al.* 2017; Min San Thein *et al*. 2017; Ohm Mar Saw *et al.* 2018). We expected to find genetic resources with

a wide variety of important agronomical traits, such as fruit shape, pest, disease, and environmental stress resistance, among others. Here, we report the results of a genetic-resource-survey trip in the northwestern part of Myanmar, Sagaing region.

Methods

From November 1 to 17, 2019, the collection of vegetable genetic resources in the Sagaing region was undertaken (Table 1). Japanese members arrived at Yangon International Airport from Japan on November 1, 2019, and joined the Myanmar Seed Bank members. The next day, this exploratory party moved to Khamti via the Mandalay International Airport by air. We collected the genetic resources available at Khamti, Lahe, and Layshi townships belonging to the Khamti district, Sagaing region. Fruit and seed samples of local varieties were collected from farmers and markets at 13 sites (Fig. 1). Information on each sample was collected via interviews, and this data included the local plant name, sowing date, harvest date, usage, and cultivation methods (Table 2). In addition, the place name and precise latitude and longitude of the collection sites were recorded using Garmin eTrex20J GPS technology (Garmin International Inc., Olathe, KS, USA). The collected accessions were stored as seeds at the Myanmar Seed Bank and subsets were transferred to the Genetic Resources Center, National Agriculture and Food Research Organization (NARO), using a standard material transfer agreement.

Results and Discussion

The Sagaing region, located in northwestern Myanmar, is a hilly and mountainous area (Photo 1).

Photo 1. Landscape of a forest in the Sagaing region

Three townships in this area, Lahe, Layshi, and Nanyun, belong to the Naga Self-Administered Zone (Naga SAZ). This zone is self-administrated by the Naga tribals. Two-thirds of the Naga inhabitants in Myanmar are Christians and one-third are Buddhists. Previous studies on the Naga SAZ have shown that the Naga inhabitants have been growing a range of traditional crops and varieties, mainly in a conventional slash-and-burn cultivation scheme in fields, as well as in home gardens and terraces. Additionally, they collect useful plants from their surrounding environment (Kawase *et al.* 2011; Yamamoto *et al*. 2011; Domon *et al.* 2015; Min San Thein *et al.* 2017; Naito *et al.* 2017). In this study, a total of 24 samples were collected, including 16 samples from *Cucumis sativus* L., two from *Cucumis melo* L., three from *Cucurbita moschata* Duchense, one from *Cucurbita maxima* Duchense ex Lam., one from *Luffa acutangula* (L.) Roxb., and one from *Momordica charantia* L (Table 3).

Table 1. Itinerary of the field survey in the Sagaing region, 2019

Date (month/day)	Day	Itinerary	Stay
11/1	Fri	Narita - Yangon	Yangon
11/2	Sat	Yangon - Mandalay - Khamti	Khamti
11/3	Sun	Khamti - Lahe	Lahe
11/4	Mon	Lahe	Lahe
11/5	Tue	Lahe - Khamti	Khamti
11/6	Wed	Khamti - Hta Man Thi - Layshi	Layshi
11/7	Thu	Layshi	Layshi
11/8	Fri	Layshi	Layshi
11/9	Sat	Layshi	Layshi
11/10	Sun	Layshi	Layshi
11/11	Mon	Layshi - Hta Man Thi - Khamti	Khamti
11/12	Tue	Khamti - Mandalay - Nay Pyi Taw	Nay Pyi Taw
11/13	Wed	Maynmar Seed Bank (Yezin)	Nay Pyi Taw
11/14	Thu	Nay Pyi Taw - Yangon	Yangon
11/15	Fri	Yangon	Yangon
11/16	Sat	Yangon - Narita (11/17)	On flight

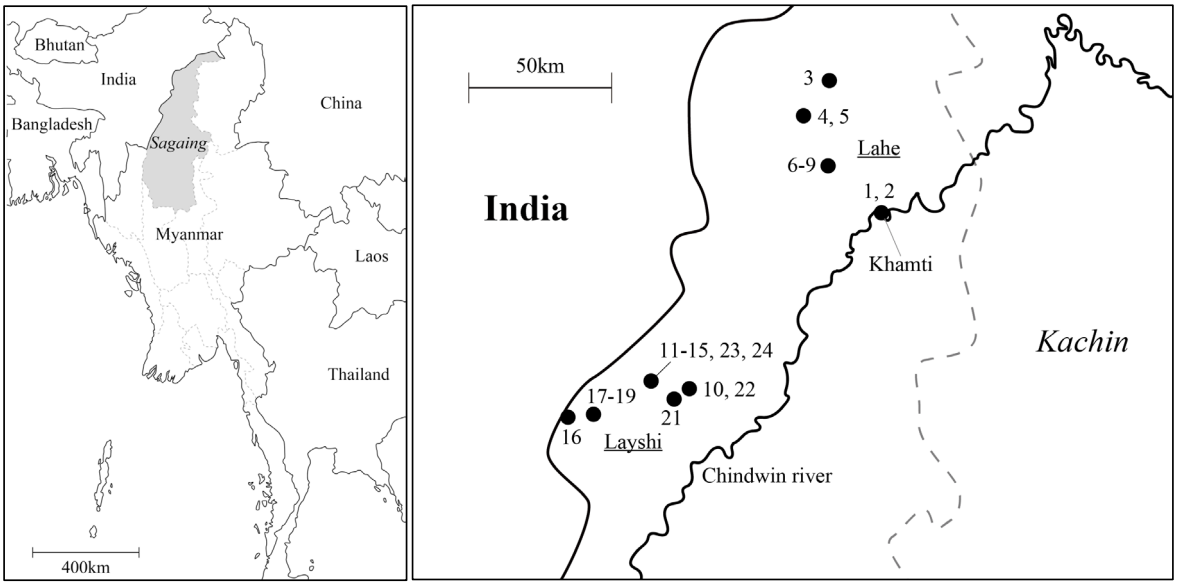

Fig. 1. Map showing the northwestern part of Myanmar. The gray shaded area is the Sagaing region (left). Figures show the number of cucumber accessions collected in each location (describe without "MYC-" of collection ID) at Khamti, Lahe, and Layshi township, and around villages (right).

Table 2. Summary of the collected genetic resources in the Sagaing region, Myanmar, 2019

Species	Total
Cucumis sativus	16
Cucurbita moschata	3
Cucumis melo	2
Cucurbita maxima	1
Luffa acutangula	1
Momordica charantia	1
Total	24

Photo 2. The main transportation method is by boat between Khamti and Hta Man Thi along the Chindwin River.

Photo 3. A variety of vegetables being displayed at a large local market, namely the Khamti market.

Khamti is the principal township in the Khamti district in the Sagaing region, along the Chindwin River (Photo 2). It is a warm area, where the average annual maximum temperature is approximately 30 °C. There is a relatively large market in the township, namely the Khamti market, where many species of crops are sold as local food sources, including Cucurbitaceae vegetables (Photo 3). We collected the seeds of pumpkin and ridge gourd (MYC-1 and 2, respectively), which were sown from September to November, and harvested from December to February. In the area around the Khamti township, farmers can cultivate crops throughout the year owing to the area's warm weather conditions.

Lahe is another one of the principal townships in the Khamti district. The town and surrounding villages are inhabited by ethnic people, who follow their own cultures, traditions, and languages. Lahe is located approximately 1,000 m above sea level, and we collected genetic resources from one village that is over 1,300 m above sea level (Photos 4–8). We collected four genetic resources from cucumbers (MYC-5, 6, 8 and 9), two from a melon (MYC-3 and 7), and one from bitter gourd (MYC-4). Some cucumbers were transferred from other areas, such as the Chin state and Gangaw district.

Photo 4. Slash-and-burn cultivation fields in Lahe township, where upland rice was cultivated; banana (that might be wild) was grown nearby.

Photo 7. Vegetables displayed at a local marketplace in Lahe township

Photo 5. A distant view of San ton village located on a slope approximately 1,300 m above sea level.

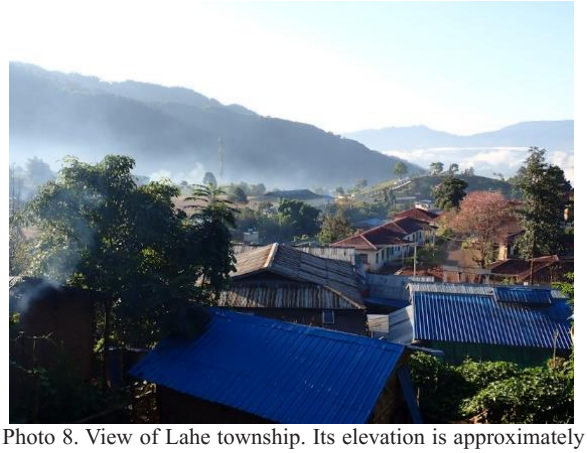

Photo 8. View of Lahe township. Its elevation is approximately 1,000 m above sea level.

Photo 6. Various crop seeds received from the village mayor in San ton

Photo 9. A traditional festival of Naga tribe being held in Layshi township.

Layshi is located in the forestry highland at approximately 1,300 m above sea level. The villages in this township are also inhabited by ethnic groups, mostly of the Naga tribes (Photo 9). We obtained cucumber and pumpkin samples that were collected from the Tung Kun Naga, Para Naga, and Makuri Naga tribes in this area. The Naga tribes practice different religions, e.g., Christianity or Buddhism, depending on each tribe, and they maintain their own cultures, traditions, and languages. Somra town and Kong Kai Lon Ywa Ma village are located close to the border shared with India, and these were the highest sites, approximately 1,900 m above sea level, from where we collected cucumber genetic resources. In Layshi, we collected 12 samples from cucumbers (MYC-10–12 and 16–24), two from *Cucurbita moschata* (MYC-13 and 14), and one from *Cucurbita maxima* (MYC-15) (Photos 10–12). The weather conditions at Lahe, Layshi, and the villages around these areas were cooler than that at Khamti. The collected accessions were stored as seeds at the

Photo 10. Farmers cultivated cucumber in their farmland using trellis. A mature fruit was used for stir-frying with other ingredient and obtaining seeds of the next generation.

Photo 11. An immature fruit of cucumber with white skin color (left) becomes brown as the fruit matures (right).

Photo 12. A farmer cultivating *C. maxima*, taking care of the fruits to prevent physical damage.

Myanmar Seed Bank and subsets were transferred to the Genetic Resources Center, NARO.

We collected 17 samples from fruits and seven from seeds. In the cucumber, a variety was observed in sample morphologies. Skin colors were orange, green, yellow, brown, and white in the mature fruit stage. Some flesh color was orange, suggesting that they might accumulate carotene during the mature stage. Almost all fruits were cylindrical; however, MYC-19 was round. The sowing season was from April to May and harvesting from August to November in Lahe, and sowing from April to July and harvesting from September to November in Layshi. The sowing and harvesting times varied depending on the climatic conditions of each farm area, such as altitude and temperature. People use cucumber fruits for fresh vegetables at the immature stage, stir-frying with other ingredients. We collected one *Cucurbita maxima* that is rarely found in this area. The farmers informed us that they obtained *Cucurbita maxima* from India a long time ago, and these are sweeter and more delicious than other pumpkins. The farmers have been maintaining the growth of this pumpkin with care, to prevent damage from disease, insects, and other animal attacks.

Acknowledgments

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ミャンマーにおける野菜遺伝資源の共同探索，2019 年

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和文摘要

本報告は農林水産省委託プロジェクト研究「海外植物遺伝資源の収集・提供強化」の予算により実施され，国立研究開発法人農業・食品産業技術総合研究機構とミャンマー植物遺伝資源センターとの間で行われたミャンマー北西部ザガイン管区におけるウリ科野菜遺伝資源の探索・収集に関わる調査報告書である．調査は 2019 年 11 月 1 日～ 17 日にかけて行った. カムティ省のカムティ郡、ラヘ郡、レイシ郡において探索・調査を行った．その結果, キュウリ（*Cucumis sativus*）16 点, ニホンカボチャ（*Cucurbita moschata*）3 点, メロン（*Cucumis melo*）2 点, セイヨウカボチャ（*Cucurbita maxima*）, トカドヘチマ（*Luffa acutangula*）およびツルレイシ（*Momordica charantia*）の計 24 点の野菜遺伝資源を収集した．収集された遺伝資源種子の半分はミャンマー農業研究局シードバンクで保存され，残りは SMTA を用いて国立研究開発法人農業・食品産業技術総合研究機構ジーンバンクに移転された.

Table 3. List of genetic resources collected in Myanmar during the 2019 survey

Coll. ID	JP No.	Coll. Date Nov. 2019	Species name	Local name	Type of sample	Status of sample	Coll. Source	Division	District	Township	Town or village name	Latitude	Longitude	Altitude (m)	Remarks
MYC-1	270780	3	*Cucurbita moschata*	Shwe Pha Yone	Landrace	Seed	Village market	Sagaing	Khamti	Khamti	Khamti	N26-00-05.42	E95-41-30.04	155	Collected at "Khamti market"; sowing from Sep. to Nov., harvesting from Dec. to Feb.; stewing and stir frying
MYC-2	270781	3	*Luffa acutangula*	Kha Wae	Landrace	Seed	Village market	Sagaing	Khamti	Khamti	Khamti	N26-00-05.42	E95-41-30.04	155	Collected at "Khamti market"; sowing from Sep. to Nov., harvesting from Dec. to Feb.; stewing and stir frying
MYC-3	270782	4	*Cucumis melo*	Khon Cho The	Landrace	Seed	Farmstore	Sagaing	Khamti	Lahe	San Ton	N26-26-17.82	E95-31-38.89	1,333	
MYC-4	270783	4	*Momordica charantia*	Khao Sha	Landrace	Fruit	Farmland	Sagaing	Khamti	Lahe	Lahe	N26-19-28.41	E95-25-27.87	987	
MYC-5	270784	5	*Cucumis sativus*	Tha Khuwar	Landrace	Fruit	Village market	Sagaing	Khamti	Lahe	Lahe	N26-19-24.69	E95-26-31.53	987	Collected at "Lahe market"; sowing in Mar., harvesting in Nov.; making salad at immature, soup at mature fruit
MYC-6	270785	5	*Cucumis sativus*	Tha Khuwar	Landrace	Seed	Farmstore	Sagaing	Khamti	Lahe	Laung Naguk	N26-09-22.97	E95-31-16.21	883	Landrace from Gangaw area; sowing from Apr. to May; harvesting from Aug. to Sep.; making salad, soup and stir frying with meet
MYC-7	270786	5	*Cucumis melo*	Tha Khuwar Ma	Landrace	Seed	Farmland	Sagaing	Khamti	Lahe	Laung Naguk	N26-09-22.97	E95-31-16.21	883	Landrace from Gangaw area
MYC-8	270787	5	*Cucumis sativus*	Tha Khuwar	Landrace	Fruit	Farmland	Sagaing	Khamti	Lahe	Laung Naguk	N26-09-22.97	E95-31-16.21	883	
MYC-9	270788	5	*Cucumis sativus*	Tha Khuwar	Landrace	Fruit	Farmland	Sagaing	Khamti	Lahe	Laung Naguk	N26-09-22.97	E95-31-16.21	883	
MYC-10	270789	6	*Cucumis sativus*	Sam Moai	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	25 mile	N25-26-52.59	E95-04-31.90	643	Landlace from Chin area; sowing in Jun., harvesting in Nov.; making salad, stir frying
MYC-11	270790	7	*Cucumis sativus*	Yge	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Sap Pyar	N25-30-03.38	E94-56-33.48	1,104	Sowing from Apr. to May, harvesting in Nov.; making salad, stir frying with chilli pepper
MYC-12	270791	7	*Cucumis sativus*	Yge	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Pain Ne Gone	N25-29-06.92	E94-57-59.87	935	Received from "Para Naga" tribe people; sowing from Jun. to Jul., harvesting from Sep. to Oct.; making salad
MYC-13	270792	7	*Cucurbita moschata*	Qhai Mpwai	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Pain Ne Gone	N25-29-06.92	E94-57-59.87	935	Received from "Para Naga" tribe people; sowing from Jun. to Jul., harvesting in Oct.; After boiling, making soup and stir frying with meet or other vegetables
MYC-14	270793	7	*Cucurbita moschata*	Qhai Mpwai Toto	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Pain Ne Gone	N25-29-06.92	E94-57-59.87	935	Received from "Para Naga" tribe people; "Toto"means white skin; sowing in Jun., harvesting in Oct.; boiling for soup and stir frying with meet or other vegetables
MYC-15	270794	7	*Cucurbita maxima*	Qhai Mpwai Toto	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Pain Ne Gone	N25-29-06.92	E94-57-59.87	935	Received from "Para Naga" tribe people; "Toto"means white skin; sowing in Jun., harvesting in Oct.; boiling for soup and stir frying with meet or other vegetables

Table 3. (Continued).

Coll. ID	JP No.	Coll. Date Nov. 2019	Species name	Local name	Type of sample	Status of sample	Coll. Source	Division	District	Township	Town or village name	Latitude	Longitude	Altitude (m)	Remarks
MYC-16	270795	8	*Cucumis sativus*	Yin Tie	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Somra	N25-21-51.03	E94-41-15.61	1,894	Received from "Tung Kun Naga" tribe people; sowing from May to Jun., harvesting from Oct. to Nov.; making salad, using dried fruit in the absence of flesh fruit
MYC-17	270796	8	*Cucumis sativus*	Yin Tie	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Kong Kai Lon Ywa Ma	N25-22-07.77	E94-45-50.99	1,907	Received from "Tung Kun Naga" tribe people; sowing from Jun. to Jul., harvesting in Sep.; making salad at immature, stir frying with meet or other vegetable at mature fruit
MYC-18	270797	8	*Cucumis sativus*	Yin Tie	Landrace	Seed	Farmland	Sagaing	Khamti	Layshi	Kong Kai Lon Ywa Ma	N25-22-07.77	E94-45-50.99	1,907	Received from "Tung Kun Naga" tribe people; sowing from Jun. to Jul., harvesting in Sep.; making salad at immature, stir frying with meet or other vegetable at mature fruit
MYC-19	270798	8	*Cucumis sativus*	Yin Tie	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Kong Kai Lon Ywa Ma	N25-22-07.77	E94-45-50.99	1,907	Received from "Tung Kun Naga" tribe people; sowing from Jun. to Jul., harvesting in Sep.; making salad at immature, stir frying with meet or other vegetable at mature fruit
MYC-20	270799	8	*Cucumis sativus*	Yin Tie	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Kong Kai Lon Ywa Ma	N25-22-07.77	E94-45-50.99	1,907	Received from "Tung Kun Naga" tribe people; sowing from Jun. to Jul., harvesting in Sep.; using flesh fruit only for hydration
MYC-21	270800	9	*Cucumis sativus*	Zam Mai	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Sone Kin	N25-25-25.79	E95-01-46.31	933	Sowing from May to Jun., harvesting in Oct.; making salad; immature fruit skin is bicolor (white and green)
MYC-22	270801	9	*Cucumis sativus*	Lu Ra	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Lhan Lai Hla	N25-26-27.86	E95-03.25.22	752	Received from "Makuri Naga" tribe people; sowing in May, harvesting in Nov.; making salad, stir frying with meet or other vegetables
MYC-23	270802	10	*Cucumis sativus*	Ygy	Landrace	Seed	Farmland	Sagaing	Khamti	Lashiy	Daing Ka Lain Away	N25-28-10.37	E94-57-05.34	1,315	Received from "Para Naga" tribe people; sowing from Apr. to Jul., harvesting from Sep. to Oct.; eating green immature fruit
MYC-24	270803	10	*Cucumis sativus*	Kgy	Landrace	Fruit	Farmland	Sagaing	Khamti	Layshi	Daing Ka Lain Sam Pya	N25-28-10.37	E94-57-05.34	1,315	Received from "Para Naga" tribe people; sowing in Apr., harvesting in Oct.; making salad

Collected samples with fruit state

Sample Photo 1.
MYC-4 (*Momordica charantia*)

Sample Photo 2.
MYC-5 (*Cucumis sativus*)

Sample Photo 3.
MYC-8 (*Cucumis sativus*)

Sample Photo 4.
MYC-9 (*Cucumis sativus*)

Sample Photo 5.
MYC-10 (*Cucumis sativus*)

Sample Photo 6.
MYC-11 (*Cucumis sativus*)

Sample Photo 7.
MYC-12 (*Cucumis sativus*)

Sample Photo 8.
MYC-13 (*Cucurbita moschata*)

Sample Photo 9.
MYC-14 (*Cucurbita moschata*)

Sample Photo 10.
MYC-15 (*Cucurbita maxima*)

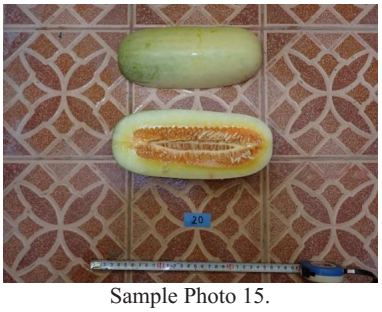
Sample Photo 11.
MYC-16 (*Cucumis sativus*)

Sample Photo 12.
MYC-17 (*Cucumis sativus*)

Collected samples with fruit state

Sample Photo 13.
MYC-19 (*Cucumis sativus*)

Sample Photo 14.
MYC-20 (*Cucumis sativus*)



Sample Photo 15.
MYC-21 (*Cucumis sativus*)

Sample Photo 16.
MYC-22 (*Cucumis sativus*)

Sample Photo 17.
MYC-24 (*Cucumis sativus*)