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Original Paper

Collaborative Survey and Collection of Brassica Vegetable Genetic Resources in and around the Southern Shan State of Myanmar

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Summary

From the 3rd to the 16th of September 2015, the Seed Bank, Biotechnology, Plant Genetic Resources and Plant Protection Division, Department of Agricultural Research, Ministry of Agriculture and Irrigation, Myanmar and the Tokyo University of Agriculture, Japan conducted a collaborative survey to collect vegetable genetic resources, especially those of brassica vegetables, in Kayah State and the southern part of Shan State in Myanmar. We collected a total of 121 samples, including five *Amaranthus* samples, 63 *Brassica juncea* (L.) Czern. samples, seven *B. oleracea* samples, including three subspecies, 18 *Capsicum* samples, 11 *Lactuca sativa* L. samples, 14 *Raphanus sativus* L. samples, and three unidentified brassica plants. The collected plant materials were divided into two subsets, with one to be conserved at Seed Bank of Myanmar and the other at Genetic Resources Center, National Agriculture and Food Research Organization, Japan, after being transferred to Japan in accordance with international and national rules. Most of the *B. oleracea* vegetables grown in the areas were improved varieties that had been introduced from foreign countries. In contrast, most of the *B. juncea* vegetables were native varieties that had been cultivated in the area for a long time. Indeed, *B. juncea* has great importance in the diet of those living in and around the southern part of Shan State and is used as fresh and dry leaf vegetables, pickles, edible oil, or essential oil that is used cosmetically. The collected *R. sativus* samples were landraces that were mostly consumed locally as oilseed and as a root vegetable. A large diversity of *B. juncea* in Myanmar was observed in morphological and physiological characters and quality traits in this survey. We suggest

that the genetic diversity of *B. juncea* is conserved in Myanmar, which is located between two secondary centers of diversity, China and India.

KEY WORDS: Myanmar, Southern Shan State, Vegetable genetic resources, Brassicaceae

Introduction

Myanmar possesses a great diversity of crops, owing to its diverse agro-climatic conditions, ranging from tropical in the south to temperate in the north, from lowland to high snow-covered mountains, and humid to dry zones. The country includes seven states, seven regions, one union territory, five self-administered zones, and one self-administered division, and shares borders with Bangladesh, India, China, Laos, and Thailand. The topography of Myanmar varies, with mountains in the north and west, a high plateau in the east, and flat land, near sea level, in the delta and river basin in the south. The territory of Myanmar extends from 9°32´N to 28°31´N in latitude and from 92°10´E to 101°10´E in longitude and is located in the most western part of Southeast Asia. The agro-climatic diversity in Myanmar is favorable for growing a variety of crops, and the country possesses a great diversity of crop genetic resources that remain to be explored.

In 2014, the Genetic Resources Center of the National Institute of Agricultural Resources (NIAS; currently the National Agriculture and Food Research Organization, NARO) initiated a 5-year plan (Collaborative Research Project on Characterization and Evaluation of Plant Genetic Resources for Food and Agriculture) to promote the survey, characterization, and evaluation of plant genetic resources in Asian countries (PGRAsia). The PGRAsia is entrusted by the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan and the NIAS organized the research consortium with public agricultural research institutes and universities to implement this Project. The NIAS and the Department of Agriculture Research (DAR), Ministry of Agriculture and Irrigation (MOAI), Myanmar has also recognized that the MAFF Project is in line with the objective of the Memorandum of Understanding (MOU) between the DAR and NIAS that was signed on the 16th of June 2014. The NIAS has established a joint research contract with the Tokyo University of Agriculture (TUA) for the PGRAsia Project.

Accordingly, the DAR and TUA planned a collaborative survey to collect vegetable genetic resources, especially brassica vegetables, in Myanmar within the framework of the PGRAsia Project from 2015 to 2018. Areas in and around the southern part of Shan State were surveyed as the first field survey of the plan.

Methods

From the 3rd to the 16th of September 2015, the Seed Bank of DAR and TUA conducted a collaborative survey to collect vegetable genetic resources, especially those of brassica vegetables, mainly in the mountainous and hilly areas of the southern part of Shan State and part of Kayah State in Myanmar (Table 1). The selected survey sites were located in eight townships of Shan State and two townships of Kayah State, and during the survey, vegetable genetic resources were collected from farmlands, farm storage, local markets, and local administrative offices of the MOAI, along with information regarding crop uses and cultivation. When necessary, we visited and interviewed farmers, in order to document detailed information regarding crop uses and cultivation.

Table 1. Itinerary for collaborative exploration and collection of vegetables genetic resources in southern Shan state and vicinity in September, 2015

Days	Date		Route	Stay	Activities
1	3-Sep-15	Thu	Arrive Yangon (NH913 NRT 1145 - RGN 1715)	Yangon	Transfer
2	4-Sep-15	Fri	Yangon → Yezin	Yezin	Visit to DAR
3	5-Sep-15	Sat	Yezin → Kalaw	Kalaw	Exploration & Collection
4	6-Sep-15	Sun	Kalaw → Aungban	Aungban	Exploration & Collection
5	7-Sep-15	Mon	Aungban → Lawksawk → Pindaya	Pindaya	Exploration & Collection
6	8-Sep-15	Tue	Pindaya → Heho → Nyaungshwe	Nyaungshwe	Exploration & Collection
7	9-Sep-15	Wed	Nyaungshwe → Inle area → Nyaungshwe	Nyaungshwe	Exploration & Collection
8	10-Sep-15	Thu	Nyaungshwe → Taunggyi	Taunggyi	Exploration & Collection
9	11-Sep-15	Fri	Taunggyi → Loikaw	Loikaw	Exploration & Collection
10	12-Sep-15	Sat	Loikaw → Pinlaung	Pinlaung	Exploration & Collection
11	13-Sep-15	Sun	Pinlaung → Yezin	Yezin	Exploration & Collection
12	14-Sep-15	Mon	Yezin	Yezin	Seed cleaning/Preparation of SMTA
13	15-Sep-15	Tue	Yezin → Yangon	Yangon	Transfer
14	16-Sep-15	Wed	Leave Yangon (NH914 RGN 2210 -)	On a plane	Transfer
15	17-Sep-15	Thu	Arrive Narita (- NRT 0645)		

DAR: Department of Agriculture Research
SMTA: The Standard Material Transfer Agreement

Results

We surveyed eight townships in Shan State and two townships in Kayah State (20°11'08"N - 21°14'17"N, 96°33'43"E - 97°35'49"E; altitude of 876 to 1499 m). The geographical and topographical differences in these areas are very wide. The mountainous region included the townships of Kalaw, Taunggyi, and Pinlaung, and the hilly or undulating lands included the townships of Aungban and Pindaya. Meanwhile, the townships of Heho, Lawksauk, and Loikaw occured in valleys, and the township of Nyaungshwe, which is located in the Inle area, was constantly flooded.

We collected a total of 121 samples, including five *Amaranthus* samples, 63 *Brassica juncea* samples, seven *B. oleracea* samples, including three subspecies, 18 *Capsicum* samples, 11 *Lactuca sativa* samples, 14 *Raphanus sativus* samples, and three unidentified brassica plants (Table 2). Of the materials collected, 119 were landraces, of which 44 were obtained from local markets, 65 from farmlands, six from farm storage, and four from local DOA (Department of Agriculture) offices. In the local markets, seedsmen, who come from the surrounding villages, sell both agricultural products, such as beans and spices, and seeds of various crop landraces that they have gathered from their home and neighboring villages (Photos 1-4).

The collected materials were divided into two subsets. One was conserved for further research and crop improvement at the Seed Bank of the Plant Biotechnology, Plant Genetic Resources and Plant Protection Department, DAR, MOAI, which is located in Yezin, Nay Pyi Taw, Myanmar. The other was transferred to and conserved at at the NIAS Genetic Resources Center at Tsukuba, Japan, under a Standard Material Transfer Agreement (SMTA) for the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) of the United Nations (UN) Food and Agriculture Organization (FAO) and a phytosanitary certificate that was issued by the Plant Quarantine Office of DOA, Yangon, Myanmar to Japan.

Brassica oleracea L.: In the southern part of Shan State, *Brassica oleracea* vegetables, such as cabbage, cauliflower, and Chinese kale, served as important cash crops, and the villages produced huge amounts of these crops and marketed them to all parts of Myanmar (Photo 5). Meanwhile, *B. oleracea* vegetables that were grown in the area were mostly improved varieties that had been introduced from

foreign countries. Only Collection Nos.37 and 38 (*B. oleracea* vars. *capitata* and *italica*, respectively), which were collected from farm storage in the township of Pyindaya, were local landraces and had been cultivated in the area for about 50 years (Photo 6). The farmers produced both cauliflower and cabbage seeds. In addition, *B. oleracea*, var. *alboglabra* was collected from three townships in Shan State, and in the township of Taunggi, we observed that *B. oleracea* var. *alboglabra* (No.83) seed was being produced in an isolated field that was enclosed within a brick wall (Photo 7).

Brassica juncea (L.) Czern. (brown mustard): Most of the collected *B. juncea* samples were native varieties that had been cultivated in the region for a long time, and species was observed vary widely in leaf shap (obovate, spathulate, or ovate; Photo 8), petiole and midrib width (narrow or slightly wide; Photos 9 and 10), petiole and midrib color (white or green; Photos 11 and 12), and pungency (none, weak, or strong). Although *B. juncea* was usually sown in October, it can be grown year round, and we observed plants at various growth stages, including seedling stage (Photo 13), harvesting stage (Photo 14), flowering stage (Photo 15), and even ripening stage (Photo 16). In the southern part of Shan State, *B. juncea* is an important dietary component and is consumed as fresh and dry leaf vegetables (Photos 17 and 18), pickles (Photo 19), and edible oil (Photo 20) or used as a cosmetic essential oil (Photo 21). Of the 63 samples collected, five (Nos. 34, 40, 49, 110, and 111) were used for oil. During the survey, we were unable to identify whether the collected samples belonged to Cernua Group, Integrifolia Group, or otherwise. Therefore, the samples will be fully identified after they are grown in Japan.

Raphanus sativus L. (radish): The 14 *R. sativus* samples, which were collected from six townships, were landraces, and most of the production was locally consumed. We observed many radishes, with root length of ~ 20 cm, at the markets (Photo 22). Radish is grown as oilseed (Photo 23) and as a root vegetable in the region, and Collections Nos. 33, 41, 50, and 75 were only grown for oil (Photo 24). Farmers usually grow the crop from October to January.

Other vegetables: The most frequently collected non-brassica crop was *Lactuca sativa* L., which was collected from five townships. Farmers produce the seed for self-consumption in backyard garden near their house.

Discussion

The *B. juncea* plants observed in Myanmar during the present survey exhibited wide variation in various characters. The crop is believed to have originated in central Asia or the Himalayas, with migration to three secondary centers in India, China and the Caucasus (Hemingway, 1995). *Brassica juncea* is grown as oilseed in India (brown or Indian mustard) and as a leaf vegetable in China, where leaf mustards have their greatest differentiation (Rakow, 2014; Singh *et al.*, 2014). We suggest that the genetic diversity of *B. juncea* is conserved in Myanmar, which is located between two secondary centers of diversity, China and India.

The leaves and seeds of *B. juncea* are rich in glucosinolates and isothiocyanates, which are beneficial on human health (Ishida *et al.*, 2014; Shahzadi *et al.*, 2015). Therefore, in order to improve brassica vegetables, the major glucosinolate and isothiocyanate components found in the edible parts of the *B. juncea* genetic resources should be investigated using both quantitative and qualitative analyses.

We also concluded that other areas of Myanmar should be systematically explored for additional genetic resources of *B. juncea* and other vegetables as soon as possible, since economic changes, urbanization, and lifestyle changes may facilitate the rapid genetic erosion of traditional vegetables.

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ミャンマー連邦共和国シャン州南部におけるアブラナ科野菜類の遺伝資源探索収集

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和文摘要

ミャンマー連邦共和国のシャン州南部、およびカヤー州の一部において，主としてアブラナ科野菜類を対象に，遺伝資源探索収集調査を 2015 年 9 月 3 日～ 16 日にかけて実施した．その結果，キャベツ類の 7 点（キャベツ 1 点，カリフラワー 1 点，カイラン 5 点），カラシナ類 63 点，ダイコン類 14 点のアブラナ科野菜類とアマランサス属植物 5 点，トウガラシ属植物 18 点，未同定のアブラナ属植物 3 点の計 121 点の遺伝資源を収集した．収集品は 2 分し、一方はミャンマー・シードバンクで、他方は国際および国内法に従って日本に導入され、農業・食品産業技術総合研究機構・遺伝資源センターにて保存される．シャン州南部および隣接地域では，キャベツやカリフラワーは換金作物として地域に普及しているため，改良品種がほとんどであった．他方，カラシナ類は地域に伝統的に栽培されている地方品種が優占していた．カラシナ類は地域の食生活に欠かせない重要な野菜で，新鮮なあるいは乾燥野菜の利用のみならず，漬け物や，精油し食用あるいはスキンケアとしての利用がみられた．ダイコン類も伝統的品種が多く，収集した 4 点はカラシナと同様に種子から精油し，油利用されていた．

ミャンマーのカラシナ類には，葉形，葉柄・中肋の幅と色，辛みなど多様な変異が存在することが確認された．インドや中国は，カラシナ類の多様性 2 次センターで，両国の間に位置するミャンマーは，国内の他地域においてもカラシナ類遺伝資源が豊富に存在すると推察された．

Table 2. A list of plant materials collected in Southern Shan state and vicinity in 2015

Coll. No.	JP No.	Species	Crops	Local name	Date of collection	Collection Sites		Name of village/ market	Latitude	Longitude	Altitude	Collection source	Status	Usage
1	256525	*Amaranthus* sp.	Amaranthus	Hinnunwe	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′17″N	96°36′22″E	1356	farmland	landrace	leaf vegetable
2	256526	*Lactuca sativa* L.	Lettuce	Salad	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′17″N	96°36′22″E	1356	farmland	landrace	leaf vegetable
3	256527	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′17″N	96°36′22″E	1356	farmland	landrace	leaf vegetable
4	256528	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenyinsein	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′23″N	96°36′29″E	1350	farmland	landrace	leaf vegetable
5	256529	*Brassica* sp.	-	-	1-Sep-15	Bago region	Hlegu T.S.	Htakkyat market	-	-	-	commercial market	-	-
6	256530	*Capsicum* sp.	Red Pepper	Ngayotehti	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′23″N	96°36′29″E	1350	farmland	landrace	spice
7	256531	*Raphanus sativus* L.	Radish	Monelat U	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′23″N	96°36′29″E	1350	farmland	landrace	vegetable
8	256532	*Brassica juncea* (L.) Czern.	Brown Mustard	Monehyinsein or Monehyinkha	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′43″N	96°36′22″E	1360	farmland	landrace	vegetable
9	256533	*Amaranthus* sp.	Amaranthus	Hinnunwe	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′43″N	96°36′22″E	1360	farmland	weedy	leaf vegetable
10	256534	*Lactuca sativa* L.	Lettuce	Salad	5-Sep-15	Shan State	Kalaw T.S.	Myinmahti	20°35′43″N	96°36′22″E	1360	farmland	landrace	leaf vegetable
11	256535	*Brassica juncea* (L.) Czern.	Brown Mustard	Monehnyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
12	256536	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
13	256537	*Lactuca sativa* L.	Lettuce	Salad	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
14	256538	*Amaranthus* sp.	Amaranthus	Hinnunwe	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
15	256539	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
16	256540	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
17	256541	*Raphanus sativus* L.	Radish	Monelat U	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
18	256542	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
19	256543	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
20	256544	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
21	256545	*Capsicum* sp.	Red Pepper	Ngayotehti	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	spice
22	256546	*Capsicum* sp.	Red Pepper	Ngayotehti	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	spice
23	256547	*Raphanus sativus* L.	Radish	Monelat U	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
24	256548	*Lactuca sativa* L.	Lettuce	Salad	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
25	256549	*Lactuca sativa* L.	Lettuce	Salad	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	leaf vegetable
26	256550	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
27	256551	*Raphanus sativus* L.	Radish	Monelat U	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
28	256552	*Capsicum* sp.	Red Pepper	Ngayotehti	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	spice
29	256553	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable

Table 2. Continued.

Coll. No.	JP No.	Species	Crops	Local name	Date of collection	Collection Sites		Name of village/ market	Latitude	Longitude	Altitude	Collection source	Status	Usage
30	256554	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
31	256555	*Raphanus sativus* L.	Radish	Monelat U	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
32	256556	*Brassica* sp.	Unknown	-	6-Sep-15	Shan State	Kalaw T.S.	Kalaw market	20°38′13″N	96°33′43″E	1325	commercial market	landrace	vegetable
33	256557	*Raphanus sativus* L.	Radish	Monelat U	6-Sep-15	Shan State	Aungban T.S.	Aungban	20°39′14″N	96°38′02″E	1284	farmstore	landrace	oil
34	256558	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Aungban T.S.	Aungban	20°39′14″N	96°38′02″E	1284	farmstore	landrace	oil
35	256559	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	6-Sep-15	Shan State	Aungban T.S.	Aungban	20°39′14″N	96°38′02″E	1284	farmland	landrace	vegetable
36	256560	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	7-Sep-15	Shan State	Pindaya T.S.	Pindaya	20°56′32″N	96°39′45″E	1199	farmstore	landrace	vegetable
37	256561	*Brassica oleracea* L. *Capitata* Group	Cabbage	Kobi	7-Sep-15	Shan State	Pindaya T.S.	Pindaya	20°56′35″N	96°39′51″E	1205	farmstore	landrace	vegetable
38	256562	*Brassica oleracea* L. *Botrytis* Group	Cauliflower	Pangawbi	7-Sep-15	Shan State	Pindaya T.S.	Pindaya	20°56′35″N	96°39′51″E	1205	farmstore	landrace	vegetable
39	256563	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	7-Sep-15	Shan State	Pindaya T.S.	Kyutsu	20°59′06″N	96°40′48″E	1139	farmland	landrace	leaf vegetable
40	256564	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	7-Sep-15	Shan State	Pindaya T.S.	Minein	21°03′58″N	96°42′58″E	1018	farmland	landrace	oil
41	256565	*Raphanus sativus* L.	Radish	Monelat U	7-Sep-15	Shan State	Pindaya T.S.	Minein	21°03′58″N	96°42′58″E	1018	farmland	landrace	oil
42	256566	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	7-Sep-15	Shan State	Pindaya T.S.	Minein	21°04′10″N	96°42′53″E	1029	farmland	landrace	leaf vegetable
43	256567	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	7-Sep-15	Shan State	Pindaya T.S.	Minein	21°04′10″N	96°42′53″E	1029	farmland	landrace	leaf vegetable
44	256568	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	7-Sep-15	Shan State	Lawksauk T.S.	Thatyettronepin	21°10′08″N	96°40′48″E	1176	farmland	landrace	leaf vegetable
45	256569	*Capsicum* sp.	Red Pepper	Ngayotehti	7-Sep-15	Shan State	Lawksauk T.S.	Thatyettronepin	21°10′08″N	96°40′48″E	1176	farmland	landrace	spice
46	256570	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	7-Sep-15	Shan State	Lawksauk T.S.	Thatyettronepin	21°10′08″N	96°40′48″E	1176	farmland	landrace	leaf vegetable
47	256571	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	7-Sep-15	Shan State	Lawksauk T.S.	Thatyettronepin	21°10′08″N	96°40′48″E	1176	farmland	landrace	leaf vegetable
48	256572	*Capsicum* sp.	Red Pepper	Ngayotehti	7-Sep-15	Shan State	Lawksauk T.S.	Thatyettronepin	21°10′08″N	96°40′48″E	1176	farmland	landrace	spice
49	256573	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	7-Sep-15	Shan State	Lawksauk T.S.	Warpyar	21°14′17″N	96°52′55″E	914	farmland	landrace	oil
50	256574	*Raphanus sativus* L.	Radish	Simonelat	7-Sep-15	Shan State	Lawksauk T.S.	Letoe	21°14′17″N	96°52′55″E	914	institute	landrace	oil
51	256575	*Raphanus sativus* L.	Radish	Simonelat	7-Sep-15	Shan State	Lawksauk T.S.	Letoe	21°13′55″N	96°51′09″E	947	farmland	landrace	oil/vegetable
52	256576	*Capsicum* sp.	Red Pepper	Ngayotehti	7-Sep-15	Shan State	Pindaya T.S.	Pindaya	20°56′35″N	96°39′51″E	1205	farmstore	landrace	spice
53	256577	*Capsicum* sp.	Red Pepper	Ngayotehti	7-Sep-15	Shan State	Pindaya T.S.	Kyutsu	20°59′06″N	96°40′48″E	1139	farmland	landrace	spice
54	256578	*Amaranthus* sp.	Amaranthus	Hinnunwe	7-Sep-15	Shan State	Lawksauk T.S.	Lawksauk	21°14′17″N	96°52′55″E	914	institute	landrace	leaf vegetable

Table 2. Continued.

Coll. No.	JP No.	Species	Crops	Local name	Date of collection	Collection Sites		Name of village/ market	Latitude	Longitude	Altitude	Collection source	Status	Usage
55	256579	*Brassica oleracea* L. *Alboglabra* Group	Chinese kale	Kailan	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
56	256580	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
57	256581	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
58	256582	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
59	256583	*Brassica* sp.	Brown Mustard/ Chinese kale	-	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
60	256584	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinpyu	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
61	256585	*Raphanus sativus* L.	Radish	Monelat U	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	vegetable
62	256586	*Raphanus sativus* L.	Radish	Monelat U	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	vegetable
63	256587	*Lactuca sativa* L.	Lettuce	Salad	8-Sep-15	Shan State	Heho T.S.	Heho market	20°43′23″N	96°49′18″E	1161	commercial market	landrace	leaf vegetable
64	256588	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinseinapya	7-Sep-15	Shan State	Pindaya T.S.	Pindaya market	20°56′32″N	96°39′45″E	1199	commercial market	landrace	leaf vegetable
65	256589	*Raphanus sativus* L.	Radish	Monelat U	7-Sep-15	Shan State	Pindaya T.S.	Pindaya market	20°56′32″N	96°39′45″E	1199	commercial market	landrace	vegetable
66	256590	*Lactuca sativa* L.	Lettuce	Salad	7-Sep-15	Shan State	Pindaya T.S.	Pindaya market	20°56′32″N	96°39′45″E	1199	commercial market	landrace	leaf vegetable
67	256591	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	9-Sep-15	Shan State	Nyaungshwe T.S.	Ngachaung	20°30′54″N	96°53′40″E	883	farmland	landrace	leaf vegetable
68	256592	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	9-Sep-15	Shan State	Nyaungshwe T.S.	Ngachaung	20°30′54″N	96°53′40″E	883	farmland	landrace	leaf vegetable
69	256593	*Capsicum* sp.	Red Pepper	Ngayotehti	9-Sep-15	Shan State	Nyaungshwe T.S.	Ngachaung	20°30′54″N	96°53′40″E	883	farmland	landrace	spice
70	256594	*Capsicum* sp.	Red Pepper	Ngayotehti	9-Sep-15	Shan State	Nyaungshwe T.S.	Ngachaung	20°30′54″N	96°53′40″E	883	farmland	landrace	spice
71	256595	*Brassica juncea* (L.) Czern.	Brown Mustard	Kutmon	9-Sep-15	Shan State	Nyaungshwe T.S.	Mwepywe	20°30′21″N	96°53′55″E	876	farmland	landrace	leaf vegetable / pickles
72	256596	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	9-Sep-15	Shan State	Nyaungshwe T.S.	Mwepywe	20°30′21″N	96°53′55″E	876	farmland	landrace	leaf vegetable / pickles
73	256597	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	10-Sep-15	Shan State	Nyaungshwe T.S.	Phaungdawoo Market	20°29′26″N	96°53′30″E	893	commercial market	landrace	leaf vegetable
74	256598	*Capsicum* sp.	Red Pepper	Ngayotehti	10-Sep-15	Shan State	Nyaungshwe T.S.	Phaungdawoo Market	20°29′26″N	96°53′30″E	893	commercial market	landrace	spice
75	256599	*Raphanus sativus* L.	Radish	Simonelat	10-Sep-15	Shan State	Taunggi T.S.	Taunggi	20°47′45″N	97°02′17″E	1457	institute	landrace	oil
76	256600	*Amaranthus* sp.	Amaranthus	Hinnunwe	10-Sep-15	Shan State	Taunggi T.S.	Taunggi	20°47′45″N	97°02′17″E	1457	institute	landrace	leaf vegetable
77	256601	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	10-Sep-15	Shan State	Taunggi T.S.	Phayarphyu	20°48′38″N	97°03′35″E	1034	farmland	landrace	leaf vegetable / pickles
78	256602	*Brassica oleracea* L. Alboglabra Group	Chinese kale	Kailan	10-Sep-15	Shan State	Taunggi T.S.	Phayarphyu	20°48′38″N	97°03′35″E	1034	farmland	landrace	leaf vegetable
79	256603	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	10-Sep-15	Shan State	Taunggi T.S.	Phayarphyu	20°48′38″N	97°03′35″E	1034	farmland	landrace	leaf vegetable

Table 2. Continued.

Coll. No.	JP No.	Species	Crops	Local name	Date of collection	Collection Sites		Name of village/ market	Latitude	Longitude	Altitude	Collection source	Status	Usage
80	256604	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	10-Sep-15	Shan State	Taunggi T.S.	Phayarphyu	20°48′38″N	97°03′35″E	1034	farmland	landrace	leaf vegetable / pickles
81	256605	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	10-Sep-15	Shan State	Taunggi T.S.	Phayarphyu	20°48′38″N	97°03′35″E	1034	farmland	landrace	leaf vegetable
82	256606	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinme	10-Sep-15	Shan State	Taunggi T.S.	Uyi	20°48′37″N	97°03′16″E	1499	farmland	landrace	leaf vegetable / pickles
83	256607	*Brassica oleracea* L. *Alboglabra* Group	Chinese kale	Kailan	10-Sep-15	Shan State	Taunggi T.S.	Uyi	20°48′37″N	97°03′16″E	1499	farmland	landrace	leaf vegetable
84	256608	*Lactuca sativa* L.	Lettuce	Salad	10-Sep-15	Shan State	Taunggi T.S.	Uyi	20°48′37″N	97°03′16″E	1499	farmland	landrace	leaf vegetable
85	256609	*Capsicum* sp.	Red Pepper	Ngayotehti	10-Sep-15	Shan State	Taunggi T.S.	Uyi	20°48′37″N	97°03′16″E	1499	farmland	landrace	spice
86	256610	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	10-Sep-15	Shan State	Taunggi T.S.	Uyi	20°48′37″N	97°03′16″E	1499	farmland	landrace	leaf vegetable
87	256611	*Brassica juncea* (L.) Czern.	Brown Mustard	Damonehyin	11-Sep-15	Shan State	Taunggi T.S.	Nanfu	20°49′26″N	97°01′18″E	1048	farmland	landrace	leaf vegetable
88	256612	*Brassica oleracea* L. *Alboglabra* Group	Chinese kale	Kailan	11-Sep-15	Shan State	Taunggi T.S.	Nanfu	20°49′26″N	97°01′18″E	1048	farmland	landrace	leaf vegetable
89	256613	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
90	256614	*Capsicum* sp.	Red Pepper	Ngayotehti	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	spice
91	256615	*Capsicum* sp.	Red Pepper	Ngayotehti	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	spice
92	256616	*Raphanus sativus* L.	Radish	Monelat U	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
93	256617	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	11-Sep-15	Shan State	Naungtaya T.S.	Witpingyi	20°11′29″N	96°45′18″E	1479	farmland	landrace	leaf vegetable
94	256618	*Brassica juncea* (L.) Czern.	Brown Mustard	Kailan	11-Sep-15	Shan State	Naungtaya T.S.	Witpingyi	20°11′29″N	96°45′18″E	1479	farmland	landrace	leaf vegetable
95	256619	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	11-Sep-15	Kayah State	Pinlaung T.S.	Naungwo	19°57′36″N	96°55′07″E	1036	farmland	landrace	leaf vegetable
96	256620	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyinsein	11-Sep-15	Kayah State	Pinlaung T.S.	Naungwo	19°57′36″N	96°55′07″E	1036	farmland	landrace	leaf vegetable
97	256621	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
98	256622	*Brassica juncea* (L.) Czern.	Brown Mustard	Monenhyin	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
99	256623	*Lactuca sativa* L.	Lettuce	Salad	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
100	256624	*Lactuca sativa* L.	Lettuce	Salad	11-Sep-15	Shan State	Taunggi T.S.	Taunggi Market	20°46′55″N	97°02′10″E	1467	commercial market	landrace	leaf vegetable
101	256625	*Capsicum* sp.	Red Pepper	Ngayout	12-Sep-15	Kayah State	Loikaw T.S.	Kone Thar	19°34′47″N	97°08′56″E	905	farmland	landrace	spice
102	256626	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Me	12-Sep-15	Kayah State	Loikaw T.S.	Kone Thar	19°34′47″N	97°08′56″E	885	farmland	landrace	leaf vegetable
103	256627	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Sein	12-Sep-15	Kayah State	Loikaw T.S.	Kone Thar	19°34′47″N	97°08′56″E	888	farmland	landrace	leaf vegetable
104	256628	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Sein	12-Sep-15	Kayah State	Loikaw T.S.	Kone Thar	19°34′47″N	97°08′56″E	888	farmland	landrace	leaf vegetable
105	256629	*Capsicum* sp.	Red Pepper	Ngayout	12-Sep-15	Kayah State	Loikaw T.S.	Kone Thar	19°34′47″N	97°08′56″E	888	farmland	landrace	spice

Table 2. Continued.

Coll. No.	JP No.	Species	Crops	Local name	Date of collection	Collection Sites		Name of village/ market	Latitude	Longitude	Altitude	Collection source	Status	Usage
106	256630	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Phyu	12-Sep-15	Kayah State	Loikaw T.S.	Thi Pow Kalow	19°28′48″N	97°12′37″E	941	farmland	landrace	Leaf vegetable
107	256631	*Capsicum* sp.	Red Pepper	Ngayout	12-Sep-15	Kayah State	Loikaw T.S.	Thi Pow Kalow	19°28′48″N	97°12′37″E	941	farmland	landrace	spice
108	256632	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Me, Mon Nyin Phyu	13-Sep-15	Kayah State	Pinlaung T.S.	Le Kyar	20°09′35″N	97°45′46″E	1450	farmland	landrace	Leaf vegetable
109	256633	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Me, Mon Nyin Phyu	13-Sep-15	Kayah State	Pinlaung T.S.	Le Kyar	20°09′35″N	97°45′46″E	1450	farmland	landrace	Leaf vegetable
110	256634	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Me, Mon Nyin Phyu, Mon Nyin Kha	13-Sep-15	Kayah State	Pinlaung T.S.	Le Kyar	20°09′35″N	97°45′46″E	1450	farmland	landrace	Leaf vegetable, oil
111	256635	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Kha	13-Sep-15	Kayah State	Pinlaung T.S.	Le Kyar	20°09′35″N	97°45′46″E	1450	farmland	landrace	Leaf vegetable, oil
112	256636	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Me	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	Leaf vegetable
113	256637	*Capsicum* sp.	Red Pepper	Ngayout	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	spice
114	256638	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Phyu	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	Leaf vegetable
115	256639	*Lactuca sativa* L.	Lettuce	Salad	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	Leaf vegetable
116	256640	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Sein	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	Leaf vegetable
117	256641	*Brassica oleracea* L. *Alboglabra* Group	Chinese kale	Kailan	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′04″N	97°46′59″E	1467	farmland	landrace	Leaf vegetable
118	256642	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin Phyu, Mon Nyin Kha	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′53″N	97°47′28″E	1481	farmland	landrace	Leaf vegetable
119	256643	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′53″N	97°47′28″E	1481	farmland	landrace	Leaf vegetable
120	256644	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin	13-Sep-15	Kayah State	Pinlaung T.S.	Yin Mee	20°04′53″N	97°47′28″E	1481	farmland	landrace	Leaf vegetable
121	256645	*Brassica juncea* (L.) Czern.	Brown Mustard	Mon Nyin	6-Sep-15	Shan State	Aungban T.S.	Hin Khar Pin	20°42′03″N	97°35′59″E	-	farmland	landrace	Leaf vegetable

Photo 1. Seedsman A.

Photo 2. Seedsman B.

Photo 3. Seeds of various crop landraces of seedsman A.

Photo 4. Seeds of various crop landraces of seedsman B.

Photo 5. Cauliflower production.

Photo 6. Older varieties (left: cauliflower, right: cabbage.)

Photo 7. The seed production of Chinese kale.

Photo 8. Leaf blade shape in outline (left: spathulate, right: obovate).

Photo 9. Slightly wide type of petiole or midrib width.

Photo 10. Narrow type of petiole or midrib width.

Photo 11. White tytpe of petiole or midrib color.

Photo 12. Green type of petiole or midrib color.

Photo 13. Seedling stage of *B. juncea.*

Photo 14. Harvesting stage of *B. juncea.*

Photo 15. Flowering stage of *B. juncea.*

Photo 16. Ripening stage of *B. juncea.*

Photo 17. Flesh vegetables of *B. juncea.*

Photo 18. Dry vegetables of *B. juncea.*

Photo 19. Pickles of *B. juncea*.

Photo 20. Oil of *B. juncea*.

Photo 21. Essential oil for skin of *B. juncea*.

Photo 22. Radish at the market.

Photo 23. The oilseeds and oil of *R. sativus*.

Photo 24. Radish plant for the oilseeds.