

Grain Amaranths Research in Nepal

Kazuhiro NEMOTO, Bimal Kumal BANIYA^{*,1},
Mineo MINAMI and Akio UJIHARA

Department of Bioscience and Biotechnology,
Faculty of Agriculture, Shinshu University

*Nepal Agricultural Research Council, Kumaltar,
Kathmandu, Nepal

Summary. This paper reviewed the results of research activity of NHCRP (National Hill Crops Research Program) on grain amaranths in Nepal such as those on the collection, evaluation and utilization of the germplasm and information of field survey, and also referred to academic studies using Nepalese grain amaranths materials in Nepal and other countries.

Keywords : grain amaranths, *Amaranthus*, genetic resources, Nepal.

Introduction

Grain amaranth (*Amaranthus* sp.) is one of the pseudocereals like as buckwheat and chenopod. Three species in the genus *Amaranthus* are called 'grain amaranths'. All of them have a large terminal inflorescence producing numerous edible seeds. *A. hypochondriacus* L. and *A. cruentus* L. were domesticated in Central America and *A. cruentus* L. was in South America²⁷⁾, by the Incas and Aztecs at least 2000 years ago²⁶⁾. After the Spanish conquest, however, cultivation of grain amaranth was prohibited by Spanish owing to the religious use, and cultivation reduced drastically thereafter.

At present grain amaranths are cultivated sporadically in Asia, especially in the countries on the southern slope of the Himalayas, rather than in the place of origin. This area is very diverse in its topography, climate and agro-ecology, and there are many landraces of grain amaranths. Nepal is located in the center of the Himalayas and two species of grain amaranths, i.e., *A. hypochondriacus* (Photo 1) and *A. caudatus* (Photo 2), are cultivated widely as a cereal and a edible green in

mountainous areas.

The noticeable botanical traits of grain amaranths such as high yielding ability and nutritive value as a high protein diet were recently discovered. In particular, grain amaranths were spotlighted suddenly since National Academy of Sciences, USA, picked it up as one of the promising crops in developing countries in the tropics¹³⁾.

A pioneering research work on this crop in Nepal has been done at National Hill Crops Research Program (NHCRP), Kabre, which belongs to Nepal Agricultural Research Council (NARC). The center started the collection, evaluation, documentation and utilization of grain amaranths germplasm from 1986. And the first author (K.N.) belonged to it and participated in these activities from July 1992 to November 1994.

This paper reports mainly the research activities of NHCRP for grain amaranths in Nepal and also refers to academic studies using Nepalese grain amaranths materials in Nepal and other countries.

Germplasm Collection and Conservation

Germplasm collection activities

Germplasm collection is essential to crop improvement and the germplasm is an indispensable material for plant breeders. The International Board for Plant Genetic Resources

Received 5 December

Accepted 19 December

¹The former director of National Hill Crops Research Program, Nepal.

Table 1. Vertical and regional distribution of *Amaranthus* sp. accessions stored in NHCRP.

Altitude \ Area (m)	Far-Western ¹⁾			Mid-Western			Western			Central			Eastern			Total		
	hy ²⁾	ca ³⁾	ots ⁴⁾	hy	ca	ots	hy	ca	ots	hy	ca	ots	hy	ca	ots	hy	ca	ots
2500-3000	1 ⁵⁾			18	6	2	1									20	6	2
2000-2500	17			17	3	3	3	1		7	3		1			45	7	3
1500-2000	13			3	2	1	1			11	2		7			35	4	1
1000-1500	20			3			2			4	2		5			34	2	
500-1000	8			1												9		
0- 500		1				1	6									6		2
Total	59	1		42	11	7	13	1		22	7		13			149	19	8

¹⁾See Fig. 1, ²⁾*A. hypochondriacus*, ³⁾*A. caudatus*, ⁴⁾Other species, ⁵⁾No. of accessions
(Data from Nemoto 1995¹⁵⁾)

(IBPGR; the present International Plant Genetic Resources Institute, IPGRI), Rome, recognized the necessity of collecting Nepalese genetic resources for their genetic diversities, and organized exploration missions for collecting various crops including grain amaranths in 1984 and 1985. Moreover, amaranths germplasm were collected by Yanagihara who was deputed by IBPGR/USDA (United States Department of Agriculture) from 1985 to 1987¹⁾, and by Ujihara and others of Shinshu University, Japan from 1982 to 1990¹⁾. Also NHCRP has carried out the germplasm collection work several times since it was established in 1986.

Table 1 shows vertical and regional distribution of the accessions preserved by NHCRP. Most of the germplasm are *A. hypochondriacus* (149 accessions) and others are *A. caudatus* (19 accessions) and wild and vegetable type (8 accessions). These accessions were collected from eastern to far-western region and ranged in altitude from 105 m to 2990 m. In particular many accessions were collected in mid- and far-western region above 1000 m, where grain amaranths cultivation is prevalent.

Preservation

All the accessions collected by IBPGR missions were shared between Nepal and Japan. In Nepal, most of the germplasm (189 accessions) are stored under ambient condition at NHCRP and others in medium-term storage in NARC. In Japan, most of IBPGR collection (132 accessions), all of the collections by NHCRP (177 accessions) and by Shinshu University (93 accessions) are preserved

in medium-term storage at Shinshu University, Ina, Nagano.

Evaluation and Characterization of the Germplasm

NHCRP evaluated 70 accessions in 1990¹⁾ and 176 accessions in 1994¹⁷⁾ (Photo 3) at Kabre (1750 m) according to IBPGR descriptors⁶⁾. Results of the experiment in 1994 are as follows;

Wide variations were observed in days to heading and first flowering, plant height, size, shape and color of inflorescence and seed characters (Tables 2, 3 and 4). The earliest heading and flowering strains were collected in highland at about 2500 m in Mustang district, western region, while the latest maturing strains were collected at 105 m in Terai zone where is in lowland near the border on India.

Grain amaranths have a brilliantly colored inflorescence, which is never observed in gramineous crops. Especially various colors of inflorescence were observed in *A. hypochondriacus* (Table 3). In most of regions purple red color had the highest percentage. In *A. caudatus*, only red and white color were observed and their proportions were significantly different among regions.

Both waxy and non-waxy perisperms have been found in the seeds of *A. hypochondriacus* collected in Lantang valley²⁵⁾. Our results on the form of starch stored in the seed and the seed coat color show that the white (pale yellow) colored seed with waxy form starch of *A. hypochondriacus* is dominant in Nepal. Sakamoto²⁴⁾ sup-

Table 2. Main characteristics of *A. hypochondriacus* and *A. caudatus*.

Species	Region ¹⁾	Days to heading	Days to first flowering	Plant height (cm)	Inflorescence length (cm)	No. of spikelets	Spikelet length (cm)	No. of branches of spikelet
<i>A. hypochondriacus</i>	FW	81.3 ³⁾	104.0	212.2	60.5	68.8	17.5	7.5
	(56) ²⁾	71-93 ⁴⁾	86-119	165-255	46-83	21-116	11-23	2-19
	MW	79.9	103.1	179.2	552.9	65.6	15.6	7.7
	(41)	70-89	90-115	137-209	40-70	38-123	7-23	3-12
	W	82.2	111.7	180.1	51.4	65.9	15.6	7.8
	(12)	63-92	84-132	146-208	38-66	27-101	11-20	5-10
	C	84.2	113.4	213.7	61.4	68.6	19.5	7.8
	(22)	80-88	94-117	161-251	44-70	56-87	15-25	1-10
	E	85.9	112.1	189.9	56.2	58.3	17.7	7.5
	(10)	80-93	105-117	151-204	45-63	44-81	11-23	6-9
Total	81.7	106.4	167.6	57.3	66.8	17.7	7.5	
(141)	63-93	84-132	137-255	38-83	21-123	7-25	1-19	
<i>A. caudatus</i>	(19)	82.4	102.6	167.6	50.6	69.9	12.2	3.5
		78-88	92-112	145-216	30-72	52-99	8-18	0-7

¹⁾See Fig. 1: FW ; Far-Western, MW ; Mid-Western, W ; Western, C ; Central, E ; Eastern,

²⁾No. of strains, ³⁾Average, ⁴⁾Range (Data from Nemoto 1995¹⁵⁾)

Table 3. Variation of color of inflorescence (Percentage to the plants of each species investigated in each region).

Region ¹⁾	<i>A. hypochondriacus</i>									<i>A. caudatus</i>			
	N ²⁾	PpR ³⁾	Pi ⁴⁾	SPi ⁵⁾	BrPi ⁶⁾	BrOg ⁷⁾	YO ⁸⁾	YP ⁹⁾	Yellow	YG ¹⁰⁾	N	Red	White
FW	(641)	42		25	2	3		1	16	11			
MW	(504)	45	2	15	5	23	3		1	6	(110)	22	78
W	(121)	46	1	35				1	7	10	(11)	100	
C	(255)	20		41	10		9	10	6	4	(45)	82	18
E	(86)	34	4	12	1			2	31	16			

¹⁾See the footnote of Table 2, ²⁾Total no. of plants investigated, ³⁾Purple Red, ⁴⁾Pink, ⁵⁾Salmon Pink, ⁶⁾Brown Pink, ⁷⁾Brown Orange, ⁸⁾Yellow Orange, ⁹⁾Yellow Pink, ¹⁰⁾Yellow Green (Data from Nemoto 1995¹⁵⁾)

Table 4. Variation and distribution of seed coat color and seed storage starch (Percentage to the total of plants investigated in each region).

Region ¹⁾	<i>A. hypochondriacus</i>					<i>A. caudatus</i>			
	N ²⁾	White		Dark brown		N ²⁾	Red	White	Dark brown
		waxy	non waxy	waxy	non waxy		non waxy	non waxy	non waxy
FW	(56)	70.5	0.3	29.1	0.1				
MW	(41)	58.8	0.3	19.5	6.2	(13)	15.2	2.0	2.0
W	(12)	72.9	0.1	19.8		(1)	7.2		
C	(22)	68.1	1.8	0.6		(5)	29.5		
E	(10)	64.0	5.0	31.0					

¹⁾See the footnote of Table 2, ²⁾Total no. of strains investigated (Data from Nemoto 1995¹⁵⁾)



Photo 1



Photo 2



Photo 3

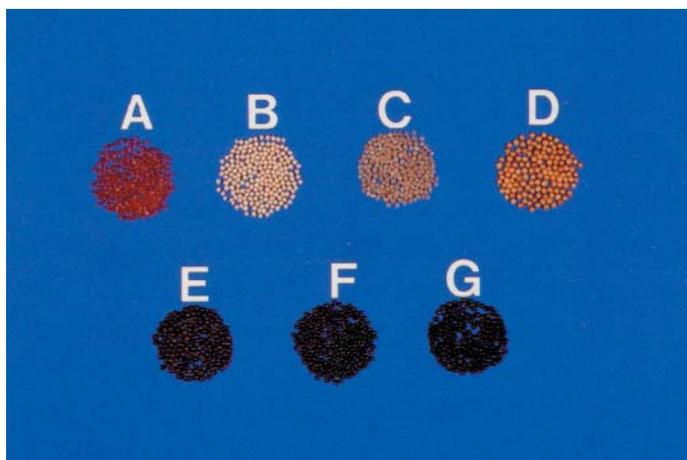


Photo 4

Photo 1. *A. hypochondriacus* ; erect inflorescence.

Photo 2. *A. caudatus* ; by the drooping inflorescence, the species are easily distinguished from the above.

Photo 3. Experiment field of grain amaranth for the germplasm evaluation and characterization at Kabre, Nepal in 1994.

Photo 4. Variation of seed coat color of grain amaranth. : A ; *A. caudatus*, B to G ; *A. hypochondriacus*. B : waxy form. C : non-waxy form. B is more white than C.



Photo 5



Photo 8



Photo 6



Photo 9



Photo 7



Photo 10

Photo 5. Mixed cropping field of *A. caudatus* with finger millet (*E. coracana*) and foxtail millet (*S. italica*) at Dolpa, mid-western region of Nepal.

Photo 6. Monocropping field of *A. hypochondriacus* at Goichan village, far-western region of Nepal. ; the seeds produced here are exported to India.

Photo 7. Harvesting of *A. hypochondriacus*. ; inflorescences are cut and dried on the field for a couple of days, then threshed.

Photo 8. Sweet snack (front one) made of popped amaranth grain at Mahendranagar bazaar. ; Local people call it 'laddoo'.

Photo 9. Girls are holding an armful of amaranth seedlings thinned. The seedlings are used for vegetable.

Photo 10. Grain amaranth (*A. hypochondriacus*) sold by cereal merchant in Nepalganj bazaar. The grain is transported from mountain area.

Table 5. Characteristics of morphological groups, “Nepal” and “Spike”.

Characters	“Nepal”	“Spike”
Height at maturity :	• 1.8 to 2.1 m	• 0.9 to 1.5 m ; shortest <i>A. hypochondriacus</i>
Days to maturity :	Late : later than “Spike” and “Mercado”, earlier than “Aztec” and “Mexico”	• Early to mid ; earliest maturing <i>A. hypochondriacus</i>
Branching :	• (1) transplanted at low density : branches at lower stem ; (2) directly seeded at high density : unbranched	• Unbranched at high density
Inflorescence :	• Stiff ; flowers tend to be less dense than “Mercado” ; prickly, more prickly than “Mercado”	• Prickly ; many long, moderately thick-fingered panicles, inflorescence compose half the plant height on many accessions
Bracts :	• Long	• Long
Shattering :	• Matures too late to assess shattering	• Moderate to sever
Pigment :	• (1) Inflorescenc : green, pink, red : green flowers may turn pink as flower matures ; (2) leaves and stem ; green, rufescent, on variegated	• (1) Inflorescenc : green, red ; (2) leaves and stem : in juvenile stage, green with red patch, a few red with green patch
Seed color :	• White, gold, brown	• Dark brown, a few white
Seed size :	• Medium to large	• Medium to large
Comments :		• All “Spike” types are segregated from : “Nepal” grain type accessions. However, we have been unable to develop uniform “Spike” lines. The plants tend to lodge since have a thin main stem and branches that cannot support the large inflorescence.

(Cited from the report of Rodale Research Center and National Academy of Sciences 1986²⁾)

posed that this would not be caused by a preference of waxy form to non-waxy form but a result of selection for more white seed coat (Photo 4). On the other hand, *A. caudatus* has only non-waxy form starch and almost red in their coat color (Table 4).

As the work in foreign contries, Rodale Research Center, USA evaluated the grain amaranth genetic resources collected from Asia and Central and South America²⁾. In the report of the center, *A. hypochondriacus* accessions were classified into five morphological groups, i. e., Mercado, Nepal, Spike, Aztec and Mexico, and Nepalese accessions were divided into the two groups, Nepal and Spike (Table 5).

At Shinshu University, Minami *et al.*^{11,12)}, Tominaga *et al.*²⁷⁾ and Nemoto *et al.*^{16,17,18,19)} evaluated the Nepalese accessions as genetic resources and observed considerable variations in several characteristics including germination pattern and seed characters.

Varietal Improvement Program in NHCRP

NHCRP started the activity on varietal improvement of grain amaranth (only for *A. hypochondriacus* at present). In the process of germplasm evaluation, several promising lines were selected by their high grain yield. The following trials using these lines were conducted in 1991¹⁴⁾;

Advanced Observation Nursery (AON)

The nursery included both local and exotic lines that were introduced from Rodale Research Center and planted in diverse agro-ecological environments, i. e., Kabre, Kumaltar (Kathmandu, 1340 m), Surkhet (660 m), Doti (560 m) and Dolpa (2350 m) (Fig. 1). At each site all the lines were evaluated for the grain yield, days to 50 % flowering and maturity, plant height, disease infection rate and so on. Lines showing good performance, 9 out of 64, at each site were selected for next trial.

Initial Evaluation Trial (IET)

The trial was carried out at Kabre, Doti and



Fig. 1. Route of field survey for grain amaranth in Nepal.

Table 6. Yield performance obtained in Coordinated Varietal Trial (CVT), 1991.

Strain No. \ Site ¹⁾	Surkhet	Doti	Kabre
	Grain yield (kg/ha)		
GA5025	74	1192	128
GA5028	167	897	181
GA5020	102	1132	247
GA18-3	102	812	206
GA5027	472	1389	143
GA67-3	469	1299	149
GA5041	170	722	100
GA42-3	92	271	12
Local	-	501	-

¹⁾ See Fig. 1 (Data from Annual Report of National Hill Crops Research Program, Nepal 1992⁴⁾)

Dolpa by using 12 lines selected in previous year. The grain yield at Kabre was very low owing to the heavy rainfall. The mean grain yield of GA5028 was the highest (615 kg/ha), followed by GA5025 (512 kg/ha) and GA218 (512 kg/ha). Nine out of 12 lines were selected.

Coordinated Varietal Trial (CVT)

The trial was conducted by 9 lines selected in 1990. The objective of this trial was to determine superior varieties of grain amaranth for different agro-ecological regions. The trial was carried out at Surkhet, Doti and Kabre. GA5027 and GA67-3 were the best and the second best yielding lines,

which yielded 472 and 1389 kg/ha, and 469 and 1299 kg/ha in Surkhet and Doti, respectively (Table 6). On the other hand, in Kabre, GA5020 was the best. These high yielding lines are now tested by Farmers' Field Trial.

Field Survey

Information on cultivation, utilization and ethnobotany of the grain amaranth are very important not only for making the breeding program but also for extending the research domains. However these information were insufficient because the field survey on grain amaranth had hardly been done. Therefore, a series of field surveys (Rapid Rural Appraisal Treks³⁾) were undertaken by the NHCRP^{21,22,23)} in the mountain areas from eastern to far-western region (Fig. 1.) from September 1992 to May 1994. In these survey we observed farmer fields and interviewed local people as well as collected germplasm.

Cultivation practice

In the western part of Nepal grain amaranths were cultivated by various methods. Mostly it was intercropped with maize (*Zea mays* L.), finger millet (*Eleusine coracana* Gaertn), foxtail millet (*Setaria italica* Beauv.), proso millet (*Panicum miliaceum* L.), blackgram (*Vigna*

mungo L.), horsegram *Macrotyloma uniflorum* (Lam.) Verdcourt and so on (Photo 5), and sometimes on the border of maize and finger millet field, and in the kitchen garden also. Monocropping field of grain amaranth (Photos 6 and 7), where seeds for export to India were produced as described later, was very few. In the eastern region, on the other hand, it was often observed to use only natural seedlings as vegetable (Photo 9).

Utilization

The white grains are popped and utilized in various forms as follows; mixed with tea or with milk and sugar (*kheer*), in the form of sweet pudding (*halwa*), ground to make non-fermented bread (*chapaties*), mixed with sugar syrup to make sweet balls (*laddoo*, Photo 8), and mixed with honey to make flat round sweets. Some of them are eaten as the religious foods only permitted to take on Days of Fast, yet nutritive values are not recognized. Also the seedlings and the fresh young leaves are used as vegetable (Photo 9).

Export to India

Sainju (1989)²⁴⁾ described in the 'Importance of Minor Crops in Nepal' that amaranth was the only hill crop with established export potential. Actually it is the fact that white seed of *A. hypochondriacus* is exported to India. However, little had been known in detail about this until the survey was carried out later.

Seeds of *A. hypochondriacus* cultivated in the hills of both mid- and far-western regions, especially Bhjng district, are brought to the nearest local bazaar by the growers and exported to India by track by way of Dhangadhi or Nepalganj (Photo 10). The growers bartered the seeds for salt from India by 1kg to 3kg. Finally, the seeds were sold 11 to 13 Nepal Rupees (about 25 yen) / kg to India. The total amount of grain amaranth exported to India was estimated approximately 100 tons per year; 90 tons from Dhangadhi and 10 tons from Nepalganj, respectively.

Other Studies

Studies using Nepalese amaranths performed in

the place other than NHCRP are noted below.

Jha^{7,8)}, a professor of Tribhuvan University, Nepal, reported productivity of grain amaranths under biological stress and assessment of productivity. Gudu and Gupta (1988)⁴⁾ reported that twenty male sterile plants were found in a population in Jumla, where is located in the mid-western region. The plants could be distinguished from normal plants by the color and morphology of their inflorescence. The sterility was controlled by a single recessive nuclear gene. Also the materials were used as mother plants of interspecific hybridization by these workers⁵⁾.

Concerning the wild amaranths, Jha⁹⁾ and Laucoul¹⁰⁾ reported. The latter described the ecological study of wild amaranths in Kathmandu valley. Studies on vernacular name of amaranths in Nepal were also described by Jha⁹⁾ and Nemoto²²⁾.

Current Studies at Shinshu University

The phylogenetic studies on grain amaranths in Asia are now in progress from both morphological and molecular aspects by Nemoto, Minami and Ujihara at Shinshu University. They have collected seed samples not only from Nepal but also from India, Pakistan, Sri Lanka, Bhutan, Myanmar, Thai, China and New world and analyzed their genetic diversity and geographical distribution. Nemoto *et al.*¹⁸⁾ investigated the inflorescence structure in detail and visualize the difference in the structure among strains. Also Nemoto *et al.*²⁰⁾ made a preliminary study on the

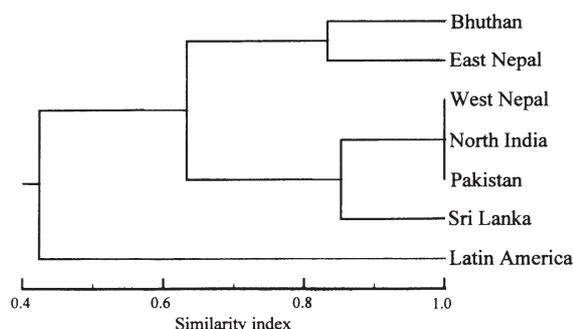


Fig. 2. A dendrogram of *A. hypochondriacus* based on RAPD data using UPGMA cluster analysis (Nemoto *et al.* 1997¹⁹⁾).

intraspecific genetic diversity of *A. hypochondriacus* by using Random amplified polymorphic DNA analysis (Fig. 2). By these studies, phylogenetic differentiation of grain amaranths in Asia and its diffusion routes is now being clarified gradually.

References

- 1) Baniya, B. K., K. W., Riley, Dongol, D. M. S. and Sherchand, K. K. : Characterization of Nepalese hill crop landraces. National Hill Crops Research Program NARC Nepal, 1992.
- 2) Proceedings of Conference co-sponsored by Rodale Research Center and the National Academy of Sciences: Descriptions of amaranth types grouped by use and physical appearance at Kutztown, Pennsylvania. Proceeding of the 3rd Amaranth Conference, pp.218-225, 1986.
- 3) Chambers, R. : Rural Development : Putting the Last First. Longman Scientific & Technical, New York, 1983.
- 4) Gudu, S. and Gupta, V.K. : Male sterility in grain amaranth (*A. hypochondriacus* ex Nepal) variety Jumla. *Euphytica* **37**, 23-26, 1988.
- 5) Gupta, V. K., and Gudu, S. : Interspecific hybrids and possible phylogenic relations in grain amaranths. *Euphytica* **52**, 33-38, 1991.
- 6) International Board for Plant Genetic Resources : Genetic Resources Amaranths-A Global Plan of Action-IBPGR Secretariat, Rome, 1981.
- 7) Jha, P. K., Sah, J. P. and Chettri, M. K. : Amaranth productivity under biological stresses. *Crop Res.* **5** 195-198.
- 8) Jha, P. K., Sah, J. P. and Chettri, M. K. : Assessment of grain amaranth productivity in Nepal. *Proc. Intl. Bot. Conf.* pp.99-106.
- 9) Jha, P. K., Sah, J. P. and Chettri, M. K. : Amaranth distribution in Nepal. *Amaranth Newsletter* No.3, 3-4, 1987.
- 10) Laucoul, P. P. : Ecological Study of Wild Amaranths in Kathmandu Valley. Tribhuvan University Master Thesis, 1989.
- 11) Minami, M., Nemoto, K., Ujihara, A. and Iizuka, M. : Genetic resources of amaranths (*Amaranthus* spp.) collected in Nepal. *Japan. J. Breed.* **41** (Suppl. 2), 178-179, 1991.
- 12) Minami, M., Yukita, T. and Ujihara, A. : On Several characteristics of amaranth (*Amaranthus* spp.) collected in Nepal. *Japan. J. Breed.* **39** (Suppl. 2), 266-267, 1989.
- 13) National Academy of Sciences : Underexploited Tropical Plants with Promising Economic Value. National Academy of Sciences, BOSTID, USA, 1975.
- 14) National Hill Crops Research Program : Annual Report 2048/2049. Nepal Agricultural Research Council, Nepal pp.87-89, 1992.
- 15) Nemoto, K. : Studies on Grain Amaranths in Nepal-Present Status of their cultivation and Utilization, and Evaluation for Genetic Resources-, Shinshu University Master Thesis, 1995.
- 16) Nemoto, K., Minami, M., Ujihara, A. and Tominaga, T. : Relationship between seed coat color and germination in Nepalese grain amaranth (*A. hypochondriacus*). *Japan J. Breed.* **42** (Suppl. 1), 368-369, 1991.
- 17) Nemoto, K., Minami, M., Ujihara, A. and Baniya, B. K. : Several characteristics of grain amaranths (*Amaranthus* sp.) in Nepal. *Japan. J. Breed.* **45** (Suppl. 1), 183, 1995.
- 18) Nemoto, K., Minami, M., Ujihara, A. and Baniya, B. K. : Waxyness and seed coat color of *Amaranthus hypochondriacus* cultivated in Nepal. *Japan. J. Breed.* **46** (Suppl. 2), 287, 1996.
- 19) Nemoto, K., Tanaka, M., Minami, M. and Ujihara, A. : The phylogenetic studies on grain amaranths in Asia. I. Morphological variation of inflorescence of *Amaranthus hypochondriacus*. *Japan. J. Breed.* **47** (Suppl. 1), 235, 1997.
- 20) Nemoto, K., Hattori, H., Yamada, Y., Minami, M. and Ujihara, A. : The phylogenetic studies on grain amaranths in Asia. II. Interspecific genetic diversity of *Amaranthus hypochondriacus* revealed by RAPD analysis. *Japan. J. Breed.* **47** (Suppl. 2), 289, 1997.
- 21) Nemoto, K., Baniya, B. K., Minami, M. and Ujihara, A. : Grain amaranths in Nepal. I. Cultivation and utilization of amaranths. *Jpn. J. Trop. Agr.* **41** (Extra issue 1), 1-2, 1997.
- 22) Nemoto, K., Baniya, B. K., Minami, M. and Ujihara, A. : Grain amaranths in Nepal. II. *Amaranthus hypochondriacus* exportation from Nepal to India. *Jpn. J. Trop. Agr.* **41** (Extra issue 1), 3-4, 1997.
- 23) Nemoto, K., Baniya, B. K., Minami, M. and Ujihara, A. : Grain amaranths in Nepal. III. Local names and farmer's consciousness. *Jpn. J. Trop. Agr.* **41** (Extra issue 2), 59-60, 1997.
- 24) Sainju, A. S. : Importance of Minor Crops in Nepal. *Agricultural Research and Production Pro-*

- ject. Kathmandu, Nepal. p.6, 1989.
- 25) Sakamoto, S.: Waxy endosperm and perisperm of cereals and grain amaranth and their geographical distributions. J. Jpn. Soc. Starch Sci. **29** (2), 41-55, 1982.
- 26) Sauer, J. D.: The grain amaranths and their relatives: a revised taxonomic and geographic survey. Annals of the Missouri Botanical Garden **52**, 103-137, 1967.
- 27) Sauer, J. D.: Grain amaranths (*Amaranthus* sp., Amaranthaceae). In "Evolution of Crops Plants" Simmonds, N. W., 4-6, 1976.
- 28) Tominaga, T., Nemoto, K., Minami, M. and Ujihara, A.: Variation in seed coat color, waxyness and seed weight of *Amaranthus* spp. in Nepal. Hokuriku Sakumotsu Gakkaiho **26**, 111-113, 1991.
-

ネパールにおけるアマランサス研究

根本和洋・B. K. BANIYA*・南 峰夫・氏原暉男

信州大学農学部応用生命科学科

*ネパール農業研究評議会, カトマンズ, ネパール

要 約

ネパールにおけるアマランサス (*Amaranthus* sp.) に関する研究について、その中心的な役割を果たしてきたネパール農業研究評議会の高地穀物研究計画がこれまでにこなってきたアマランサス遺伝資源の収集、保存、評価、育種計画、および現地調査活動について概説するとともに、ネパール産のアマランサスを用いた内外の研究についても言及した。

キーワード：アマランサス, *Amaranthus*, 遺伝資源, ネパール