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Intellectual Property Right on Basmati Rice: Current Scenario and Evidences of Origin, Diversity, Cultivation and Use Values of Basmati Rice in Nepal

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Abstract

Basmati rice, also called the king/prince of rice landraces has very special values in Nepalese society as well as in other countries of Indian Subcontinent. With the objectives of collecting, analyzing and documenting Basmati related information in Nepal, we visited different sites; carried out key informant surveys; organized focus group discussions, online interaction and discussion meetings; requested all relevant offices/ persons/ stakeholders through phone, website, and letter to share information; organized high level official meeting, and Basmati rice expert meeting; documented video documentary and did online as well as library search. Because of its high market value at global level, many countries and organizations have been attempting to get intellectual property rights (mainly patent and geographical indication tag) on Basmati rice. India applied for GI tag to Basmati rice in the European Union (EU) in July 2018, and Nepal submitted opposition letter along with proofs and evidences of origin, diversity, cultivation and use values of Basmati rice on 9 December 2020. A total 133 Basmati type rice landraces are grown in 60 districts of Nepal. Basmati rice is traditionally grown, sold, and consumed in geographically localized areas of Nepal since ancient time. International and national scientists have defined lower altitude of Nepal as one of the centers of origin of Basmati rice. Many Nepalese basmati rice landraces have been characterized and evaluated using morphological traits, isozymes and DNA markers. Four basmati type of rice landraces have been registered in National Seed Board. Many community seed banks have maintained different types of Basmati rice landraces. National Agriculture Genetic Resources Center and International genebanks have collected more than 80 and conserved 68 basmati landraces. Basmati rice landraces have geo-linked traits. The historical culture of production, consumption and marketing of native basmati rice in Nepal should always be favored by both national and international rules and regulations. Nepal has ample and valid evidences to get geographical indication (GI) right on Basmati rice.

Keywords: Geographical indication, Basmati rice, origin, diversity, historical literature

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Introduction

Rice diversities consisting of 2500 native landraces and 153 improved varieties are being grown in 75 out of 77 districts and within an altitude range from 60 to 3050 m in Nepal [1–7]. Before 1980, Nepal was exporting rice including aromatic rice to India, China, Singapore and Bangladesh [1,8–12[. In 1977, a total of 105,000-t rice was exported [1]. The word 'Basmati' is used as an adjective describing the things having aroma or fragrance. Basmati, the prince/king of rice is a valued and expensive cereal. Many landraces are very localized and possess specific traits, for instance, Basmati with aroma [2,13,14]. In general, Basmati type landraces include all aromatic rice landraces. Aromatic rice is grown in 10% of total rice area (i.e. 150,000 ha out of total 1491,744 ha rice area) with total production of 375,000t in Nepal [15]. Average productivity of such landraces is about 2.5 t/ha. Basmati rice emits aroma which could be a geographical indication (GI).

Geographical indication is a sign used on products that has a specific geographical origin and possess qualities or reputation that are due to that origin. It is a very common practice to provide GI tag to the agricultural products in the world to monopolize the marketing. Germany has the highest number of GI tagged products with 9,499, but, Nepal does not have any one [7]. A total of 361 GI products have been registered in India as of September 2019. Darjeeling tea was the first GI tagged product in India, registered in 2004. In 2010, Basmati rice also got registered as GI product in India. India has also submitted

application to EU for geographical indication tag to Basmati rice in 2018 [16]. In addition to EU, India has also sought registration of 'Basmati' in different countries.

Basmati rice is grown in Indian Subcontinent and many countries have their own native Basmati rice [16–18]. Many diverse Basmati types of rice landraces are being grown in different parts of Nepal since ancient times [1,6,14,19,20]. Therefore, the Nepalese farming communities have rights on using Basmati rice. Nepal applied opposition letter to EU with regards to GI tag to Indian Basmati rice on 9 December 2020. To be eligible to get GI tag to Basmati rice, Nepal needs to develop and generate relevant proofs and evidences. The objectives of this paper, therefore, were to compile Basmati rice related proofs and evidences of origin, diversity, cultivation and use values in Nepal; to analyze historical cases of Basmati and aromatic rice landraces and to aware and generate information about GI tag to Basmati rice.

Methodologies

Basmati rice type (which include all aromatic rice landraces) have been grown in different parts of Nepal since ancient time. There are key farmers and researchers who are well familiar with Basmati type rice landraces. Both primary and secondary data were collected, analyzed and discussed. Information related to geographical indication and Basmati rice were telecasted, published in different media and shared widely to make aware and improve understanding of geographical indication. Nine different methods to generate and compile Basmati rice related proofs and evidences were adopted. We visited 6 different sites; surveyed 15 key informants; organized 5 times focus group discussion; organized 3 times online interaction and discussion meetings; requested call through phone, email, website and different media to relevant organization across the country; organized two times high-level-official meetings; organized a Basmati rice expert consultation meeting; developed three video documentaries, and surveyed literatures. Proofs and evidences were grouped and analyzed under 10 different areas as shown in Figure 1. Database of Genesys (https://www.genesys-pgr.org/), National Genebank of Nepal and community seed banks were analyzed. Districts growing aromatic rice landraces were mapped in the country map. Total number of aromatic rice landraces was estimated based on their name given by farmers. Aromatic rice diversities were grouped under two: Basmati group (any landraces that contain at least the word Basmati in their name) and non-basmati aromatic group (any landraces that emits aroma but do not have the word Basmati in their name).

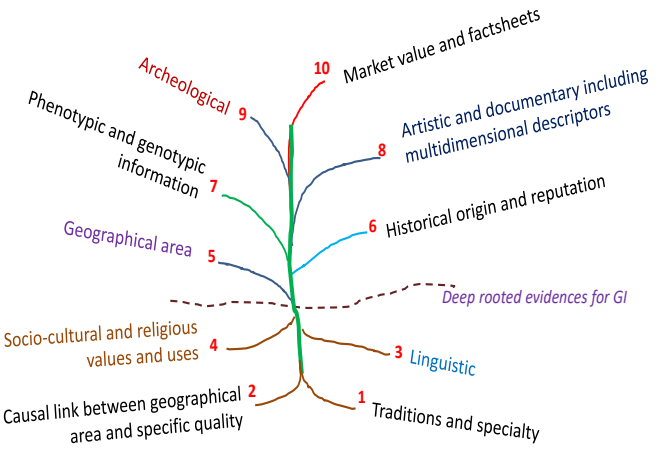

Figure 1. Groups of potential proof and evidences of origin, diversity, cultivation and use values of Basmati rice

Findings

All relevant stakeholders, farming communities, experts and high officials attended in various official meetings agreed that Basmati rice originated in Nepal and different types of Basmati rice are being grown. Basmati rice has multidimensional values associated with farming communities, wealthy people and special occasions. Farmers and researchers are also well familiar with the historical importance, diversity, market value and use of Basmati rice in Nepal.

Geographical indication in Nepal

Because of climatic variation, Nepal is rich in agrobiodiversity and some of them are produced in very specific areas e.g. Jumli Marshi, Jethobudo, Basmati, Juju Dhau, Pharping pear, etc. More than 100 agricultural products are potential for geographical indication (GI) tag in Nepal [7,21]. It is well known that if Jethobudo grows other than Pokhara valley, its quality decreases. None of the products are registered as GI in Nepal; however, there are many products including Basmati, marketed informally as GI and getting higher price for assured better quality in different parts of the country. Three traits (famous, special trait and origin) are very important on GI system. Basmati is very famous, has a very special trait and originated in Nepal, and therefore, hold capacity to get GI tag. Legally registration system as GI has not been existed in Nepal, but there is a policy provision for GI [7].

Basmati rice in Nepal and India

Basmati rice emits a specific aroma in the field, at harvesting, in storage, during milling, cooking and eating. Some landraces may emit aroma in only few stages e.g. at

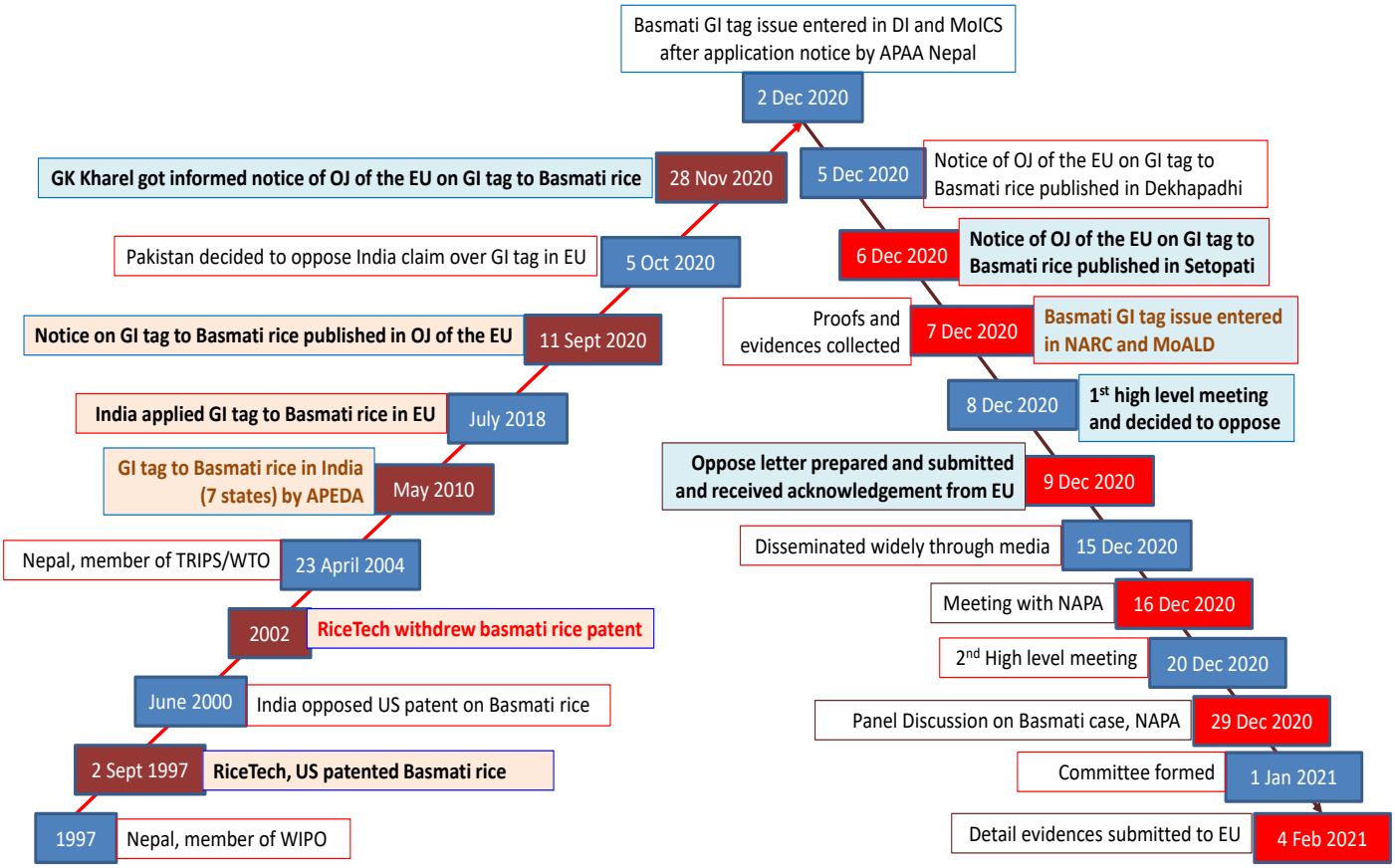

Figure 2. Historical events on intellectual property right (IPR) over Basmati Rice and its geographical indication (GI) cases in Nepal

harvesting, during cooking, etc. In Nepal Basmati type rice covers all aromatic rice landraces (short grain, medium and long grain types) and varieties [22]. It is grown in Tarai and Mid Hill agricultural ecozones. This is highly reputed rice and cost very high. Therefore, normal family cannot offer such rice all the day. Basmati rice are sold in many locations by the name of production areas. Many short and medium grain aromatic landraces are grown and consumed locally but they are not known much in the international market. In India, Basmati type rice include only long grain rice that emits aroma in most of the time [16–18,23]. Along with Basmati, many short and medium grain aromatic rice varieties are grown in different parts of India. Some of them are superior for taste and aroma as compared to long grain aromatic varieties [18]. Though Basmati rice includes all aromatic rice in Nepal, we have to standardize the Basmati rice for international trade as per the international standard including in India and Pakisan.

Relatively traditional grown Basmati rice are better in quality and aroma than Basmati varieties developed by breeder and grown in high input conditions. Tools and techniques now are available to check the adulteration of Basmati that help protect the interest of consumers and farmers [18]. Ready-to-use kit along with DNA markers could be used for Basmati authentication. An international code of practice has been developed for maintaining the reputation of Basmati rice [18].

Historical Events on IPR over Basmati Rice

Because of very highly recognized and preferred trait of Basmati rice, different types of intellectual property rights are being tried on Basmati rice around the world. For example, US-based RiceTec Company patented Basmati rice in 1997 [24]. India registered Basmati rice under the regime of geographical indication in 2010. In Nepal IPR over agricultural products and technologies are very negligible. In case of Basmati rice, Nepal applied detail proofs and evidences of origin, diversity, cultivation and use values of Basmati rice in EU in Dec 2020. Historical details of IPR over the Basmati rice and GI cases are given in **Figure 2**.

Evidences of origin, diversity, cultivation and use values of Basmati rice

Basmati rice possess geo-linked trait i.e. quality and aroma. Same genotype of Basmati rice if grown in other than its original home localities, their quality differs and could not get same quality products as produced in their native localities. This property of Basmati rice is then provided as GI tag. Many different types of information and methodologies are needed to get GI tag [21]. Evidences on aromatic rice in Nepal are described below.

Linguistic and ancient literature evidences

In literal meaning, basmati means aroma or scented [3,7,9,25]. It is made up of two Sanskrit words, 'Vas' means aroma and 'Mati' means ingrained from the origin. In Nepali language, the equivalent of Vas is Bas (aroma) and therefore, aroma related rice landraces and varieties are called Basmati. Almost all Nepali understand the meaning and importance of Basmati and Basmati rice and therefore, this word Basmati has become the very common Nepali word.

Ancient literatures have mentioned Basmati rice as an important food, nutritional and medicinal items [1,26–30]. Chandranighantu (250 years old literature) has described Sali Dhan [29,31]. Ayurved has grouped rice diversity in three categories and among them shukdhanya category includes 15 sali dhanya jaat including Basmati type [29]. Nepali literature of 1960 BS (1903 AD) reported 61 landraces including Basmati type [27]. In Lumbini, which is birth place of Lord Gautam Buddha, there is aromatic rice landrace called Kalanamak, which was used as holy grain during Baudha period (900 BC). Because of its religious important, community has started conservation works for Kalanamak rice landrace (called Bhaudhakalin Kalanamak Dhan) and reviving the culture [32,33]. The Father of Lord Budhha is the king Suddhodhan which mean pure rice with aroma. Nepal has also registered aromatic rice by this name, Suddhodhan Kalanamak. Kalanamak rice also contain high iron and zinc [34]. Many researchers have documented and published about Nepalese basmati rice landraces and many of these are available online [1,6,9,19,30,35–48].

Folklore

Basmati is common word in Nepal and has been used for giving name to ladies. Other plant species having aroma are also named with this word e.g. Basmati sponge gourd, Basmati Rayo, Basmati banana, etc. We can see some stories, poems, songs associated with Basmati in Nepal. For example, there is Deuda song in Western Nepal, "Basmati ko dhan pakya garai basai gaya" which mean during maturity, Basmati rice emits aroma and any one can feel its aroma around the field. Similarly, fair dance song called Hathhorha is held in Baisakhi festival. There is a long song this fair dance and its part ("Basmati ropanya syara O bamja Jhuprai bamja") also relate Basmati rice [49].

Traditions, specialty and reputation

Basmati rice is traditionally grown, sold, and consumed in Nepal since ancient time [1,10–12,25,33–36,44,48,50–58]. Historically, public mind always considers Basmati rice as a special grain aromatic rice grown and produced in a particular geographical area. Basmati rice landraces have geo-linked traits and they are grown in different parts of Nepal [4–7]. It is highly valued and most important rice landraces fetching premium price in the market (8,9,19,21,25,36,38,38,41,50,57,59–62).

Basmati is a group of rice landraces used on special occasion [10,51,55]. Farmers' experiences indicated that organic Basmati is far better than non-organic in quality and aroma. The aroma decreases when an aromatic rice is grown with chemical fertilizers. The application of home made compost (made up from native and local materials and livestock dungs) is a must if the real aromatic rice is to be produced. Aroma is higher in recently harvested rice over old stock. Rice dehulled with local *Dhiki* is with higher aroma as compared to grain milled in a rice huller [19]. Its straw is very soft and long therefore farmers prefer to make different home items, *Gundri, Chakati, Chataai*, etc. from its straw. Basmati rice straw is also used to make marriage-temple or house and this is very old tradition in Tarai region.

Sociocultural, economical and market value

Basmati rice has social and cultural values in Nepalese communities [10–12,14,33,52,55,57,58]. Social status is very high for those family who consume and grow aromatic rice. Common culture from ancient time is to offer Basmati rice based food items to guest, relatives, VIP, in festival, special function, marriage ceremony, etc. [57,60]. Nepali community consider Basmati rice grain as holy, pure, chokho, virgin and therefore used during fasting, offer to Gods and Goddess, and used in different religious ceremony (chhat, shraddha, etc.). It is also a component of axeta and vikxa. There are a lot of socio cultural evidences particularly in Tarai area. It is used during Ram Janaki Bibaha, in general marriage ceremony, Kul deuta pooja, etc.

Some farmers use Basmati rice grain in death ceremony and *Ritual Shraddha*. For this, they allocate separate land for continued growing of Basmati rice and harvest from this land is used during ritual program. On the day of *Shraddha*, their home use to be full of delicious rice smell. In many religious events, there is a function called *hom-halne* where aromatic rice grains are used and one can feel smell of rice around during this function.

Basmati rice has a very high economic value [19,44,59,60]. The aromatic rice is very popular in both domestic and international markets and fetches premium price. Gin and Shahi [28] reported that Nepal used to export about 200 metric tons of fine quality aromatic rice per annum earning about 4l million rupees in 1977.

Table 1. List of Basmati landraces conserved in National Genebank, Nepal

SN	Accession	Landrace	Collected site
1	NGRC01669	Jhinuwa Masino	Gorakhkali, Gorkha
2	NGRC01698	Basmati Dhan	Kalsil, Bajura
3	NGRC 01811	Basmati Dhan	Mundi, Humla
4	NGRC 01815	Basmati Dhan	Tukche, Mustang
5	NGRC 01825	Basmati Dhan	Makai, Humla
6	NGRC 01835	Sunaulo Dhan	Badhu, Bajura
7	NGRC 01867	Masino Basmati Dhan	Dhading
8	NGRC 01945	Basmati Dhan	Lalitpur
9	NGRC 01967	Kalanamak Dhan	Khungai, Rupandehi
10	NGRC 02022	Hanse Dhan	Dandagaon, Salyan
11	NGRC 02030	Basmati Dhan	Dipayal, Doti
12	NGRC 02036	Sunaulo Dhan	Martadi, Bajura
13	NGRC 02066	Hansaraj Dhan	Madigaon, Bajhang
14	NGRC 02093	Hansaraj Dhan	Manara, Dadeldhura
15	NGRC 02094	Basmati Dhan	Manara, Dadeldhura
16	NGRC 02103	Sunaulo Dhan	Bhandara, Dadeldhura
17	NGRC02821	Jhinuwa Masino	Gorkha Bazaar, Gorkha
18	NGRC03016	Kanakjira	Udayapur
19	NGRC03023	Sunaulo Ghaiya	Sanagaun -7, Doti
20	NGRC03038	Sunaulo Ghaiya	Silgadhi-9, Doti
21	NGRC03050	Sunaulo Ghaiya	Sallaghari-11, Dadeldhura
22	NGRC03051	Danda Basmati	Dasharat chand-9, Baitadi
23	NGRC03052	Danda Basmati	Dasharat chand-9, Baitadi
24	NGRC03096	Kalo Masino	Taranagar (DADO), Gorkha
25	NGRC03249	Jhinuwa Basmati Dhan	Raluka, Nuwakot
26	NGRC03268	Basmati Dhan	Thumpakhar, Sindhupalchok
27	NGRC03289	Rato Basmati Dhan	Parsa
28	NGRC03291	Rato Basmati Dhan	Bara
29	NGRC03293	Basmati Nokhi Dhan	Bara
30	NGRC03326	Kanakjira Dhan	Sunsari
31	NGRC03364	Basmati Dhan	Chhinnamasta, Saptari
32	NGRC03369	Kalanamak Dhan	Kapilvastu
33	NGRC03375	Basmati Dhan	Dhanusha
34	NGRC03389	Basmati Dhan	Beldari, Kanchanpur
35	NGRC03415	Basmati Dhan	Phulkaha Katti, Siraha
36	NGRC04999	Kalo Masino	Gaikhur, Gorkha
37	NGRC05007	Hansaraj Basmati Dhan	Chaudhari-6, Mauri bagar, Bajhang
38	NGRC05017	Hansaraj Dhan	Banjh-8, Bajhang
39	NGRC05018	Shyamjiro	Banjh-8, Bajhang
40	NGRC05691	Shyam Jira	Gadariya-1, Kailali
41	NGRC07862	Jarneli Dhan	Barpak, Gorkha
42	NGRC07869	Begani Ghaiya	Saurpani, Gorkha
43	NGRC07889	Masino Basmati	Bichaur-4, Lamjung
44	NGRC07900	Mohanbhog	Patharaiya-9, Kailali
45	NGRC07915	Kalo Jhinuwa	Ghanpokhara, Lamjung
46	NGRC07923	Lekali Basmati	Ghanpokhara, Lamjung
47	NGRC08267	Seto Basmati Dhan	Shivasatasi Municipality, Jhapa
48	NGRC08273	Kalo Tuned Basmati Dhan	Shivasatasi Municipality, Jhapa
49	NGRC08276	Chhoti Basmati Dhan	Shivasatasi Municipality, Jhapa
50	NGRC08277	Rato Basmati Dhan	Shivasatasi Municipality, Jhapa
51	NGRC08278	Hansaraj Dhan	Shivasatasi Municipality, Jhapa
52	NGRC08289	Kanakjira Basmati Dhan	Shivasatasi Municipality, Jhapa
53	NGRC08300	Jorayal Basmati Dhan	Shivasatasi Municipality, Jhapa
54	NGRC08303	Hansaraj Dhan	Shivasatasi Municipality, Jhapa
55	NGRC08308	Kalo Basmati Dhan	Shivasatasi Municipality, Jhapa
56	NGRC08372	Kalo Basmati Dhan	Kawasoti N.Pa.-14, Nawalpur
57	NGRC08442	Hansaraj Dhan	Satyawti Gaupa, Gulmi
58	NGRC08586	Basmati Dhan	Betali – 4, Ramechhap
59	Co - 10271	Hansaraj Dhan	Satyawti Gaupa, Gulmi
60	Co - 10406	Basnadaar Lamda Dhan	Sayaal -5, Doti
61	Co - 10512	Basmati Dhan	Betali - 4, Ramechhap
62	Co - 10669	Kalo Tuned Basmati	Shiwa satasi N. Pa. - 3, Jhapa
63	Co - 10681	Shyanmjira	Khjura Ga. Pa. - 4, Banke
64	Co - 10691	Basmati Dhan	Bhadrapur N. Pa. - 1, Jhapa
65	Co - 10692	Chulthe Basmati	Bhadrapur N. Pa. - 1, Jhapa

66	Co - 10751	Basmati Dhan	Bagmati - 6, Lalitpur
67	Co - 10764	Aglo Basmati Dhan	Bagmati - 7, Lalitpur
68	Co - 10765	Hocho Basmati Dhan	Bagmati - 7, Lalitpur
69	Co - 10915	Basmati Dhan	Gokulganga Ga. Pa. - 4, Ramechhap
70	Co - 11257	Kalo Basmati	Ganeshaman N. Pa. - 7, Dhanusha
71	Co - 11258	Sunaulo Sugandha	Bhartapur Mahangarpalika, Chitwan
72	Co - 11381	Gajiyabad Basmati	Bharatpur sub - MC - 19, Chitwan
73	Co - 11382	Puspa Basmati	Bharatpur sub - MC - 19, Chitwan
74	Co - 11416	Basnadar Kalo	Bharatpur sub - MC - 19, Chitwan
75	Co - 11427	Thaniya Basmati	Bharatpur sub - MC - 19, Chitwan
76	Co - 11454	Kalanamak	Bharatpur sub - MC - 19, Chitwan
77	Co - 11462	Basphool	Bharatpur sub - MC - 19, Chitwan
78	Co - 11464	Baspare	Bharatpur sub - MC - 19, Chitwan
79	Co - 11468	Basmati Paschimko	Bharatpur sub - MC - 19, Chitwan
80	Co - 11470	Jhinuwa Basmati	Bharatpur sub - MC - 19, Chitwan

Note: There are other Basmati (aromatic) type rice accessions in National Genebank of Nepal that need to further study and verification.

Many local rice millers (around 60 rice factories) are marketing basmati rice by different brand names at local and national levels. Some of native aromatic landraces are as competitive as modern varieties [8,9]. Many households prefer to grow economically valued traits ie aroma [63]. Relatively quality of Nepalese Basmati rice is better than other countries. Three landraces (Basmati, Rato Basmati, and Kalo Nuniya) are very popular aromatic landraces in Nepal and have a high market value in comparison with other varieties [64]. Basmati comes under the group of five-qualities (*Pancha Gudiya*) product in Nepal. These five qualities are purity, quality, tasty, healthy and nutritious. Some of Basmati landraces are medicinally important [29]. Basmati rice landraces milled in local mill (*dhiki*) content low glycemic index and therefore are useful for diabetes patients.

Databases

Four basmati type of rice landraces have been improved and registered in National Seed Board of Government of Nepal. They are Pokhreli Jetho Budho rice registered in 2006, Lalka basmati registered in 2010, Suddhodhan Kalanamak and Kalonuniya registered in 2020. These registrations have also been published in Nepal Gazette (Nepal Rajpatra) on different dates [3,65–67]. Many community seed banks have maintained different types of basmati rice landraces in their localities [68–70].

National Agriculture Genetic Resources Center (National Genebank) under Nepal Agricultural Research Council (NARC, www.narc.gov.np) has collected and conserved more than 80 basmati type rice accessions from different areas of Nepal (**Table 1**). There are other landraces which are Basmati type but recognized as different names. Their examples include Hansraj, Jethobudho, Jhinuwa, Kalo masino, Tilki, Ghiu puri, Begani, Jarneli, Gauriya, Kalo nuniya, Kala Namak, Kanak Jira, Kariya Kamod, Krishnabhog, Sali Dhan, Shyamjira, etc [4–6,45,71]. International genebanks (https://www.genesys-pgr.org/) has conserved more than 68 basmati rice accessions collected from different parts of Nepal (**Table 2**) and some of them were collected in early 1970s. Some of basmati type accessions conserved in the International Rice Research Institute (www.irri.org) genebank include Asamiya Basmati, Basmati, Basmati Anpjhutte, Basmati Dhan, Basmati Gola, Basmati Lamo, Basmati Masino, Basmati Nokhi, Basmati Pahade, Basmati Red, Basmati Uzarka, Basmati White, Danda Basmati, Kalo Basmati, Masino Basmati, Rato Basmati, Sete Basmati, Seto Basmati, etc. Many of these accessions conserved in IRRI has already been shared with other countries for research and utilization [67].

Table 2. Nepali rice accessions named Basmati available from Genesys

SN	Accession	Acquisition Date	Local Name
1	PI 549247	1984/12/13	Basmati mutant
2	IRGC 16213	1972/06/30	Masino Basmati
3	IRGC 23861	1972/04/05	Dhera Dun Basmati
4	IRGC 23787	1972/04/05	Basmati Dhan
5	IRGC 58881	1981/08/31	Basmati Lamo
6	IRGC 58882	1981/08/31	Basmati Masino (Purple Tip)
7	IRGC 58886	1981/08/31	Basmati Red
8	IRGC 58884	1981/08/31	Basmati Nokhi
9	IRGC 58883	1981/08/31	Basmati Masino
10	IRGC 59054	1981/08/31	Kalo Basmati
11	IRGC 58880	1981/08/31	Basmati Gola
12	IRGC 58885	1981/08/31	Basmati Pahade
13	IRGC 16136	1972/06/30	Asamiya Basmati
14	IRGC 83309	1994/09/22	Basmati
15	IRGC 83679	1994/09/22	Seto Basmati
16	IRGC 83317	1994/09/22	Basmati Mutant
17	IRGC 83316	1994/09/22	Basmati Mixed 2
18	IRGC 83650	1994/09/22	Rato Basmati
19	IRGC 83310	1994/09/22	Basmati Dhan
20	IRGC 83314	1994/09/22	Basmati Dhan

21	IRGC 83784	1994/09/22	Basmati
22	IRGC 86925	1996/10/24	Basmati Dhan
23	IRGC 83313	1994/09/22	Basmati Dhan
24	IRGC 83312	1994/09/22	Basmati Dhan
25	IRGC 83661	1994/09/22	Red Basmati
26	IRGC 83308	1994/09/22	Basmati
27	IRGC 83315	1994/09/22	Basmati Dhan
28	IRGC 88761	1995/06/02	Basmati Mixed 1
29	IRGC 83678	1994/09/22	Seto Basmati
30	IRGC 83676	1994/09/22	Sete Basmati
31	IRGC 83311	1994/09/22	Basmati Dhan
32	IRGC 16130	1972/06/30	Basmati
33	IRGC 58887	1981/08/31	Basmati White
34	IRGC 58879	1981/08/31	Basmati Anpjhutte
35	IRGC 59205	1981/08/31	Rato Basmati
36	IRGC 58888	1981/08/31	Basmati Uzarka
37	IRGC 110313	1996/10/24	Danda Basmati
38	IRGC 62000	1982/04/20	Masino Basmati
39	IRGC 117438	2008/12/15	Basmati Lamo::IRGC 58881-1
40	IRGC 127766	2011/05/01	Rato Basmati::IRGC 59205-1
41	IRGC 132324	2013/11/01	Basmati Red::IRGC 58886-2
42	IRGC 133780	2011/11/01	Basmati Dhan::IRGC 83313-1
43	IRGC 133781	2011/11/01	Basmati Dhan::IRGC 83315-1
44	IRGC 133779	2011/11/01	Basmati Dhan::IRGC 23814-1
45	IRGC 133785	2011/11/01	Basmati Gola::IRGC 58880-1
46	IRGC 133805	2011/11/01	Basmati Masino::IRGC 58883-1
47	IRGC 133810	2011/11/01	Basmati Mutant::IRGC 83317-1
48	IRGC 133824	2011/11/01	Basmati White::IRGC 58887-1
49	IRGC 133809	2011/11/01	Basmati Mixed 1::IRGC 88761-1
50	IRGC 133806	2011/11/01	Basmati Masino (Purple Tip)::IRGC 58882-1
51	IRGC 133815	2011/11/01	Basmati Nokhi::IRGC 58884-1
52	IRGC 133962	2011/11/01	Danda Basmati::IRGC 110313-1
53	IRGC 134149	2011/11/01	Kalo Basmati::IRGC 59054-1
54	IRGC 134335	2011/11/01	Rato Basmati::IRGC 83650-1
55	IRGC 134357	2011/11/01	Red Basmati::IRGC 83661-1
56	IRGC 134410	2011/11/01	Sete Basmati::IRGC 83676-1
57	IRGC 134411	2011/11/01	Seto Basmati::IRGC 83679-1
58	IRGC 134645	2011/11/01	Dhera Dun Basmati::IRGC 23861-1
59	IRGC 134791	2012/11/01	Basmati Dhan::IRGC 83310-2
60	IRGC 134792	2012/11/01	Basmati Dhan::IRGC 83312-2
61	IRGC 134836	2012/11/01	Masino Basmati::IRGC 62000-2
62	IRGC 134880	2011/11/01	Basmati Dhan::IRGC 86925-1
63	IRGC 134948	2013/11/01	Basmati Dhan::IRGC 83311-2
64	IRGC 135656	2011/11/01	Basmati Mixed 2::IRGC 83316-1
65	IRGC 135657	2011/11/01	Basmati Pahade::IRGC 58885-1
66	IRGC 135712	2014/05/01	Basmati Dhan::IRGC 83314-2
67	IRGC 136202	2015/05/01	Basmati Uzarka::IRGC 58888-2
68	IRGC 140367	2018/01/05	Seto Basmati::IRGC 83678-1

Note: There are many other Basmati (aromatic) type rice accessions (with other than Basmati name) collected from Nepal in this Genesys database. Source: [67], https://www.genesys-pgr.org/

Center of diversity

Basmati rice has been originated in Indian Subcontinent [16–18,72–74]. The center of diversity of aromatic rice are the foothills of Himalayas in the Indian states of Uttar Pradesh (UP) and Bihar, and Tarai region of Nepal [17,38,54,75] and produced in geographically localized areas of Nepal. The center of diversity and dispersal route are indicated in **Figure 3**. International and national

scientists have defined lower altitude of Nepal as one of the centers of origin of basmati rice [38,56,72,76,77]. The Tarai belt of Nepal was once considered as the bowel of aromatic rice landraces [38]. Choi et al [76] reported three major geographically structured genetic groups of aromatic rice and they are Bhutan and Nepal which is admixture of cluster 2 and 3; Bangladesh, India and Myanmar which made distinct cluster, and Iran and Pakistan which also made distinct cluster.

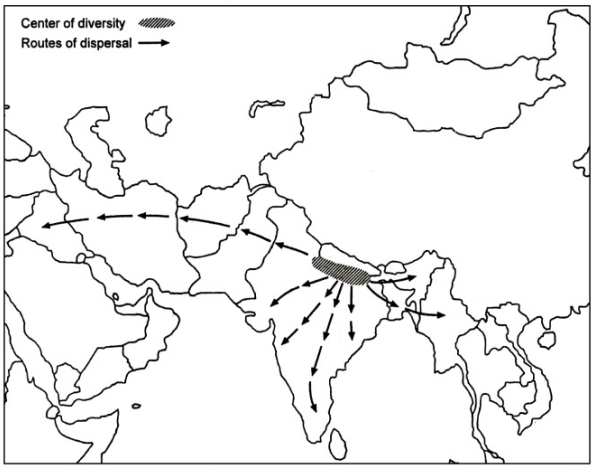

Figure 3. Center of diversity and dispersal route of aromatic rice in Asia.Source: [17]

Historical evidences and research

Ancient documents (Ayurved, Chandraniganthu), old scientific literatures [1,26,27,29,32,33] and culture of Lord Gautam Bauddha [33] have mentioned different features and uses of aromatic rice. Cultures and values associated with Basmati rice have been passed from generation to generation. Basmati rice is the most preferred by all Nepali people. Basmati rice was used by King family, very rich people, in special occasion, festival, very special function, etc. It is common culture in Nepal to offer Basmati rice to VIP and guest. Family having Basmati rice also got respected by the communities. It has been used as indicator of rich people and neighbors easily know cooking variety of rice by smelling aroma.

Research on basmati rice started in 1951 with the collection of 930 rice germplasm (including aromatic landraces) from across 54 districts and their evaluation at Parwanipur and Khumaltar [1,26] in Nepal. NARC and other organizations have been working for developing aromatic rice varieties using local basmati rice landraces since early 1960s [8,9,40,67,78–82].

Nepali students (BSc Ag) in India have also experiences of taking Basmati rice including wild rice from Nepal to India with expecting good amount of money. They remembered; teacher taught about the importance of Basmati rice and possibility of patenting this rice (Prabeen Dahal, 2020 personal communication).

Basmati rice diversity and production areas

There are many different forms of basmati rice landraces in Nepal, grown in different districts [1,4–9,19,27,30,35,38,41,50,60,61,71,83–85]. We found total 133 aromatic rice landraces by name. Among them, 43 landraces contain the words in association with Basmati in their name (**Table 1 and 2**) and 90 landraces were named by the word other than Basmati (**Box 1**). Farmers in particular area may give their own name to aromatic rice landraces introduced from other areas. Four aromatic landraces have been improved and registered in National Seed Board of Government of Nepal and two exotic aromatic varieties (Sunaulo Sugandha and Sugandhit Dhan-1) have been released for general cultivation. In IRRI Genebank, there are about 86 landraces described by the name Basmati irrespective of grain dimensions and intensity of aroma in IRRI [23].

Box 1. List of basmati (aromatic) type landraces (not named by the word basmati) in Nepal (total= 90)
Aachame Masino, Anadi Basnadar, Anjana, Bagane, Bagari, Bahani, Baharni, Barambhusi, Basnadaar Lamda Dhan, Basnadar Kalo, Baspare, Basphool, Batisara, Bayarni, Begani, Belguthi, Biramphool, Chengul, Chiniyapuri, Chirankhe, Dudhe Marsi, Gauria (Gaure), Ghaiya Rato, Ghyu Puri, Ghyu Kumari, Gude Kalo, Gude Seto, Gudgudo, Gudura, Gurdi Kalo, Gurdi Seto, Hansaraj, Hanse Dhan, Hapsa, Hapsa Rato, Indrabeli, Jaran Dhan (Kalo), Jarneli, Jaswa, Jethobudho, Jhinuwa, Jhinuwa Ghaiya, Jirasari, Jogini, Kalanamak, Kalo Bayarni, Kalo Jhinuwa, Kalo Masino, Kalo Nuniya, Kalo Nuniya Thulo, Kalo Jhinuwa, Kanak Jira, Kariya Kamod, Kasturi, Khairo Anadi, Khalte Kholo, Koili, Krishna Bhog, Krishna Charcha, Lajee, Lalbachchhi, Madhukar, Mahabhog, Mahajogani, Malbhog, Masino Jhinuwa, Motisor, Pahenle, Pakhe Jhinuwa, Pakhe Tunde, Pokhreli Masino, Pran Peuri, Rahumanuwa, Rajbhog, Ram Tulsi, Ramjoin, Sali Dhan, Samundraphinj, Seto Bayarni, Seto Jhinuwa, Shyamjira, Sisuwapanheli, Sunaulo Dhan, Sunaulo Ghaiya, Suwawat, Thapachini, Tilki, Tulsi Prasad, Tulsiphool, Tunde.

Maximum variation was observed in Nepal, followed by India and Bangladesh in aromatic germplasm [23]. Very high diversity at both phenotypic and genotypic levels in Basmati rice have been reported in Nepal [6,7,38,45,71,78,86]. Intra landrace diversity was also found commonly in many aromatic landraces [79,80]. These aromatic landraces possess very different traits and based on 12 bases, types of aromatic rice landraces and varieties along with meaning and examples are given in **Table 3**. Some are with awn and some are awnless with red, white and black grain. Based on grain size, there are three types of Basmati rice, namely short, medium and long grain Basmati rice [30,70,72,87]. Aromatic rice does not exist for deep water condition in Nepal. Rahmani and

Harinkher can also grow in shade area. Similarly Koili is shade loving aromatic landrace. Pranpyuri is very soft basmati rice landrace.

Table 3. Grouping of Nepalese rice landraces based on different criteria

SN	Basis	Type	Meaning	Example
1	Planting season	Chaite aromatic Dhan	Spring rice, transplanting in Chaitra	Tauli
		Bhadayia aromatic Dhan	Early type	Bhadaiya Basmati
		Barkhe or Agahani aromatic Dhan	Normal rice	Basmati, Kasturi, Jhinuwa, Jaswa, Chananchur, Ujrka Basmati, Lalka Basmati, Tulsi Prasad, Gopalbhog
		Hiunde aromatic Dhan	Winter or boro rice	Pakhe Masino
2	Maturity	Early aromatic rice	Early maturity	Bhadaiya Basmati, Gyu Puri
		Medium aromatic rice	Medium maturity	Thapachini, Anadi Basnadar
		Late aromatic rice	Late maturity	Gurdi, Koili, Basmati, Kasturi, Jhinuwa, Jaswa, Chananchur, Ujrka Basmati, Lalka Basmati, Tulsi Prasad, Gopalbhog, Tilki
3	Grain size	Short grain aromatic rice	Small size grain with aroma	Jethobudho, Panhele, Motisar
		Medium grain aromatic rice	Medium size grain with aroma	Mahajogani
		Long grain aromatic rice	Long size grain with aroma	Anadi Basnadhar
4	Ecosystem (production environment)	Rainfed upland aromatic rice	Unbunded condition	Suwawat, Begani Ghaiya
		Rainfed lowland aromatic rice	Bunded condition	Hansaraj, Sali Dhan
		Irrigated aromatic rice	Bunded condition	Tilki, Kalo Masino
6	Cultivation	Introduced aromatic	From abroad	Sunaulo Sugandha, Sugandhit Dhan-1
		Improved aromatic	Developed by breeder	Lalka Basmati, Sudodhan Kalanamak
		Landrace aromatic	Maintained, developed by farmers	Kariya Kamod, Krishna Bhog
7	Morphotype	Tall aromatic rice	Tall height	Kalo Masino, Anadi
		Medium aromatic rice	Medium height	Hamsaraj, Thapachiniya
		Dwarf aromatic rice	Short height	Tulsi Kathey
8	Grain color	White aromatic rice	Grain with white husk	Tauli, Hansaraj
		Black aromatic rice	Grain with black husk	Shyam Jira, Kalanamak, Kalo Nuniya
		Red aromatic rice	Grain with red husk	Begani Ghaiya, Sali Dhan
9	Photoperiod response	Aus (Saro, Gaddar or Ghaiya) aromatic rice	Mature within a certain period, photoperiod non sensitive	Ghiu Puri, Begani Ghaiya

		Aman (Agahani or Sarihan) aromatic rice	Mature at particular time, photo period sensitive	Kalanamak, Tilki, Gauriya, Ujaraka Basmati, Tulsi Prasad, Kanakjira
		Awnless aromatic rice	Grain without awn	Pokhreli Masino
10	Awn	Short awn aromatic rice	Grain with very short awn	Rato Basmati, Lalka Basmati
		Long awn aromatic rice	Grain with long awn	Seto Basmati, Hansaraj
		Complete (universal) aromatic rice	Emits aroma in all stages (field, harvesting, storage, milling, cooking and eating)	Hansaraj, Sali Dhan, Kalo Masino, Jhinuwa, Jethobudho, Kalanamak, Kalo Nuniya
11	Aroma	Partial aromatic rice	Emits aroma in only few stages (cooking and eating)	Lalka Basmati, Jorayal Basmati, Anadi, Chananchur, Jaswa, Gauriya, Ujarka Basmati
		Basmati named rice	Name has at least basmati word	Basmati, Ujarka Basmati
12	Name	Non basmati aromatic rice	Name has other than basmati word	Kasturi, Jhinuwa

Source: [1,7,19,22,36,50,52,57,61,70,86,88,89]
Source: [1,2,6,7,14,19,20,30,35,36,41,47,48, 50–53, 57,61,65,68,70,78, 81–83, 85–91]

Aromatic rice is produced in many Asian countries [18]. Aromatic rice landraces mainly Basmati, Kalanamak, Kariyakamod, Kalonuniya, Hansraj, Jethobudho, Jhinuwa, Syamjira, Tilki, etc. are being grown in more than 30,000 hectares of 41 districts in Nepal [4–6,57,65]. Aromatic rice is cultivated from East Mechi to west Mahakali. There are many Ghaiya aromatic landraces as well in Doti and Achham districts. Aromatic rice Gauri, Paranpyuri, Kalo Gude and Jhinuwa are still cultivated in small areas in Surkhet valley. Survey and literatures have shown that aromatic rices are grown in 60 districts out of 77 in Nepal (**Figure 4**). The Tarai belt was once considered as the bowel of aromatic rice landraces [38]. Altitudinal distribution of aromatic rice landraces is given in **Table 4**. Aromatic rices are grown from 60 to 1800 m altitude in Nepal.

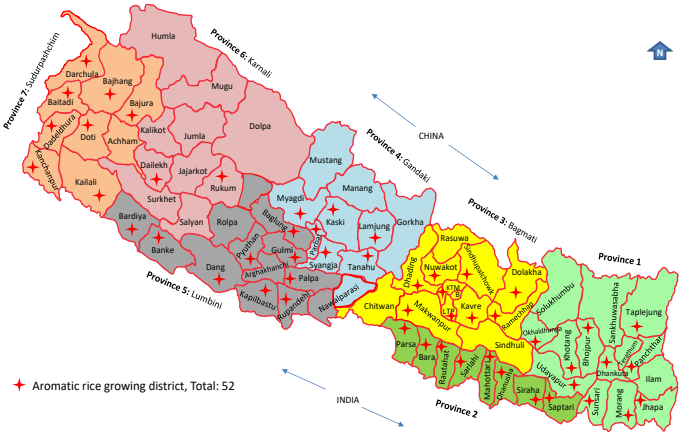

Figure 4. Districts (marked by star sign) showing cultivation of native Basmati (aromatic) type rice landraces in Nepal
Source: [1,6,7,14,19,20,51,52,65,69,70,78]

Agro-morphological and nutritional based evidences

Collection, characterization and evaluation of native aromatic rice landraces have been started since 1951 in Nepal [1,26]. A large number of landraces and introduced aromatic rice varieties were characterized and evaluated both at on-farm and on-station by many Nepalese researchers using agro-morphological traits [1,7,9,21,28,30,39,43–45,51–53,58,70,71,78–80,82,84,86–88,92]. Cooking and eating qualities are the main important features in Basmati rice. These qualities are associated with different factors. Nutritional analyses have been done in some of native and improved Basmati type rice varieties and landraces [21,22,48]. The protein content was maximum in Red Basmati (7.74%) and minimum in Black Basmati (6.51%) among the four Basmati varieties [22]. These nutritional profiles indicates that there is variation within and among different types of aromatic rice landraces grown in Nepal.

Isozymes and DNA based evidences

Many Nepalese aromatic rice landraces have been explored through isozymes and DNA markers [18,38,45,76–78,92–94]. DNA profile and fingerprints of some aromatic rice landraces using SSR markers are given in **Figure 5.** National and foreign scientists have used Nepalese aromatic rice genotypes for genetics study, molecular breeding and diversity study, and reported variation within and among landraces collected from different parts of Nepal.

Table 4. Distribution of Basmati type rice landraces in Nepal

SN	Rice Cultivar	Districts	Altitude, m
	Achhame Masino	Chitwan, Jhapa, Makawanpur, Morang	200-800
	Asamiya Basmati	Morang	<600
	Badiya Basmati	Bara, Rautahat, Parsa	<600
	Bagari	Chitawan, Siraha	60-300
	Baharni	Bara, Parsa, Saptari, Siraha	<500
	Basmati	Bara, Bajura, Dadeldhura, Darchula, Dhanusha, Doti, Humla, Jhapa, Kapilvastu, Kanchanpur, Kathmandu, Lalitpur, Mahottari, Morang, Parsa, Pyuthan, Ramechhap Rautahat, Rupandehi, Sarlahi, Siraha, Sindhupalchok, Taplejung, Udayapur	200-1000
	Basmati Anadi	Bara	<300
	Basmati Anpjhutte	Dolakha	<800
	Basmati Nokhi	Bara	<300
	Belguthi	Jhapa, Morang, Sunsari, Sankhuwasabha, Panchthar, Ilam, Jhapa, Terhathum	<800
	Biramphool	Dhading, Jhapa, Kathmandu, Kaski, Lamjung, Morang, Parbat, Siraha, Sunsari, Udayapur	400-800
	Charan Basmati	Bajura	1000
	Chengul	Bara, Parsa, Sunsari	<500
	Chhoti Basmati	Jhapa, Morang, Sunsari	<300
	Chirankhe	Bhojpur, Dhankuta, Illam, Okhaldhunga, Panchthar, Terhathum	<1800
	Chulthe	Jhapa, Sunsari	60-300
	Danda Basmati	Dadeldhura	1530
	Deradun Basmati	Bake	300
	Gauria	Arghakhanchi, Baglung, Kapilvastu, Lamjung, Myagdi, Nawalparasi, Ramechhap, Rupandehi, Sankhuwasabha, Sunsari, Terhathum	300-1400
	Ghyu Kumari	Bara, Parsa, Sarlahi, Sindhuli	<500
	Gola Basmati	Sunsari	<500
	Gude (Seto, Kalo)	Dailekh	<1100
	Gudgudo	Gulmi	<1100
	Hansraj	Bajhang, Baitadi, Darchula, Dadeldhura, Jhapa, Kanchanpur, Morang, Palpa, Pyuthan, Salyan, Sunsari, Surkhet, Syangja	60-1100
	Hapsa	Jhapa	<300
	Hapsa Rato	Jhapa	60-300
	Indrabeli	Dhading, Dhankuta, Gorkha, Lamjung	800-1400
	Jaran Dhan (Kalo)	Arghakhanchi, Bajhang, Dang, Gulmi, Jajarkot, Kaski, Parbat, Rukum, Salyan and Surkhet	800-1400
	Jaswa	Dhanusha, Mahottari, Morang, Rautahat, Saptari, Siraha, Sunsari	60-300
	Jethobudho	Kaski, Myagdi, Parbat, Sunsari, Syagnja, Tanahun	600-1250
	Jhinuwa	Baglung, Doti, Gorkha, Kailali, Kanchanpur, Kaski, Kathmandu, Lamjung, Myagdi, Nuwakot, Parbat, Shankhuwasaba, Sindhupalchok, Sunsari, Syangja, Tanahun	300-1300
	Jirasari	Jhapa, Morang, Panchthar, Ramechhap, Sunsari	<600
	Jogini	Chitwan, Ramechhap	500
	Jorayal Basmati	Doti	<800
	Jorpal Basmati	Jhapa, Morang, Sunsari	<1200
	Kalo Basmati	Dhankuta, Jhapa, Kathmandu, Morang, Sunsari	<1200
	Kalo Jhuse Basmati	Jhapa, Morang, Sunsari	<300
	Kalo Nuniya	Jhapa, Morang, Sunsari	60-300
	Kalo Nuniya Thulo	Jhapa, Morang, Sunsari	60-300
	Kalo/Kala Nimak	Bardiya, Chitwan, Nawalparasi, Rupandehi	100-400
	Kalotunde Basmati	Jhapa, Morang, Sunsari	<300
	Kanak Jira	Bara, Bardiya, Chitawan, Jhapa, Kailali, Kanchanpur, Kapilbastu, Morang, Salyan, Sunsari, Syanja	<600
	Kariya Kamod	Dhanusa, Morang, Saptari, Siraha	200-400
	Kasturi	Bara, Kailali, Parsa	500-1400
	Krishna Bhog	Achham, Dhankuta, Kanchanpur, Ramechhap	<1400
	Krishna Charcha	Bajura	<1400
	Lalbachchhi	Jhapa, Morang, Sunsari	60-300
	Lalka Basmati	Bara, Dhanusha, Parsa, Rautahat	60-300
	Lanjhi	Bara, Parsa	<500
	Lekali Basmati	Lamjung	1500

Mahabhog	Kailali, Dhading, Rasuwa, Bara, Parsa	200-600
Mahajogini	Bara, Parsa	<300
Masino Basmati	Dhading, Khotang	<900
Motisar	Bara, Parsa	<300
Pahade Basmati	Ilam	<1000
Pahenle	Bajhang, Bardiya, Gorkha, Ilam, Kaski, Lamjung, Myagdi, Palpa, Parbat, Sinduplanchok, Syanja	600-800
Pokhreli Masino	Solukhumbu, Sankhuwasabha	600-800
Pran Peuri	Sallyan, Surkhet	1200-1400
Rajbhog	Dhading, Kailali, Kanchanpur	<600
Ram Tulsi	Panchthar, Terhathum	800-1100
Ramjawain	Bara, Parsa	<600
Rato Basmati	Jhapa, Morang, Sunsari	60-300
Rato Basmati Sano	Bara, Jhapa, Mahottari, Morang, Parsa, Siraha, Sunsari	<300
Ratotunde Basmati	Jhapa, Morang, Sunsari	<300
Sali Dhan	Baitadi, Dadeldhura, Gorkha	<1200
Samundrabakhi Phim	Dhading, Nuwakot	<600
Samundraphinj	Dhading, Kaski, Makawanpur, Nuwakot	200-600
Seto Basmati	Bara, Jhapa, Morang, Parsa, Sunsari	60-300
Shyamjira	Banke, Doti, Jhapa, Kailali, Kanchanpur, Morang, Sunsari	60-300
Thapachini	Achham, Bajhang, Bajura, Dadeldhura, Kailali, Lamjung, Terhathum	200- 1400
Tulsi Prasad	Nawalparasi, Parsa, Dhanusa	200-1400
Tulsiphool	Dhanusha, Jhapa, Mahottari, Morang, Saptari, Sindhuli, Siraha, Sunsari, Udayapur	60-300
Ujarka Basmati	Bara, Parsa, Rautahat	60-300

Source: [2,4–6,14,19,63,68,90,91]

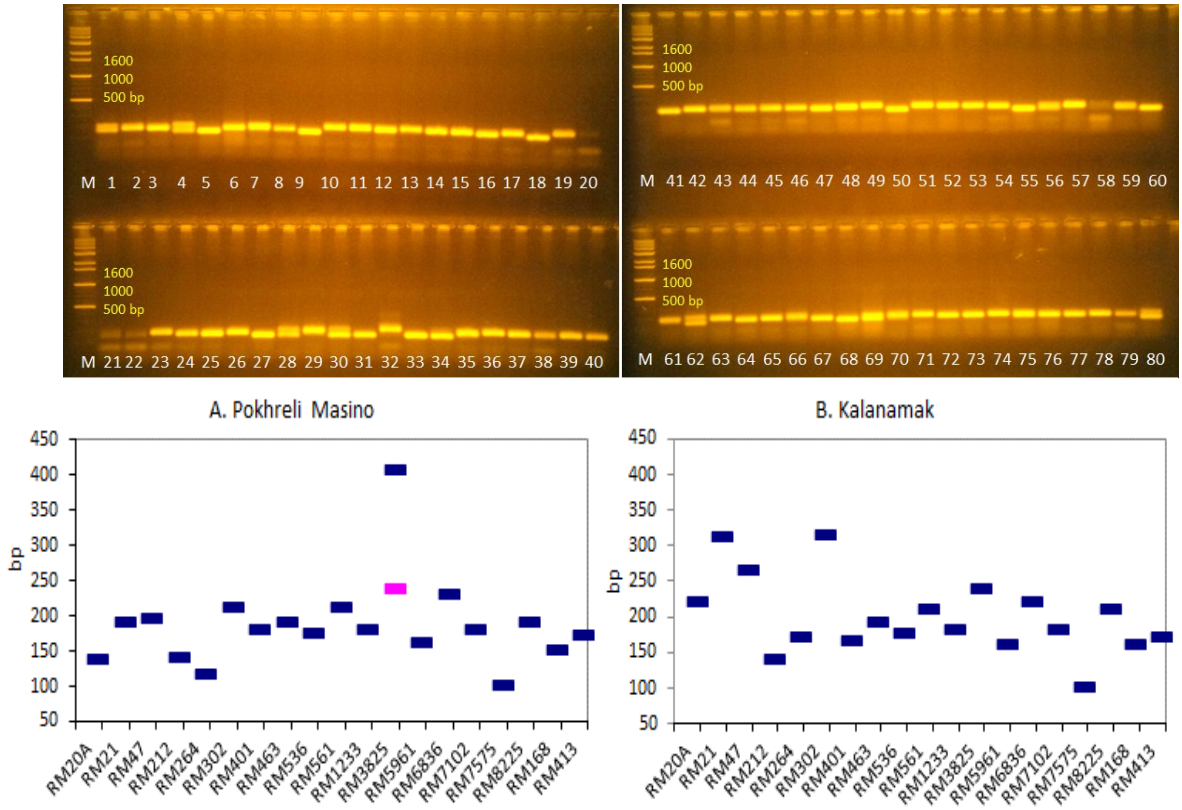

Figure 5. DNA profile of aromatic and non aromatic rice landraces (upper figure) and DNA fingerprint (down figure) of Basmati type rice landraces using SSR markers. Source: [78]

Gaps and policy implication

Research and mechanism for implication of GI is urgently needed in Nepal as this sector is neglected and underutilized. Research, development and education system should focus on native crop diversity and traditional knowledge along with traditional products and process. Documentation of different kinds of information e.g. traditional, folklore, scientific information etc. should be done for all types of native

agricultural genetic resources. Accelerated research is necessary to identify the geo-linked traits and products, and geographical indicator of genetic resources. Simple mechanism should be in place to register native agricultural products as GI at Provincial and National levels.

Conclusion

There are strong proofs and evidences of the origin, diversity, cultivation and use values of Basmati rice in Nepal based on survey, on-farm and on-station trials, lab research, and information from local, regional, national and global levels. Basmati type rice possesses quality trait for getting geographical indication tag and it includes all types of aromatic landraces i.e. short, medium and long grain Basmati rice in Nepal. Nepalese farming communities in many districts are maintaining, growing, using, marketing and sharing Basmati type rice landraces since unknown time period. The rights of Nepalese communities, therefore, should not be prohibited for production, consumption and marketing of their basmati rice landraces. Legal system for GI tag should be immediately established in Nepal and agricultural products must be registered. Harmonized system (HS) on trade should also be established separately for aromatic rice in Nepal.

Competing Interests

No competing interests.

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Ethical Approval and Consent

Not applicable

References

1. Mallick RN. Rice in Nepal. Kathmandu: Kala Prakanshan; 1981.
2. Upadhyay MP, Joshi BK. Plant Genetic Resources in SAARC Countries: Their Conservation and Management: Nepal Chapter [Internet]. SAARC Agriculture Information Center; 2003. 297–422 p. Available from: https://www.researchgate.net/publication/333641164_Plant_Genetic_Resources_in_SAARC_Countries_Their_Conservation_and_Management_Nepal_Chapter
3. Joshi BK, Bhatta MR, Ghimire KH, Khanal M, Gurung SB, Dhakal R, et al. Released and Promising Crop Varieties of Mountain Agriculture in Nepal (1959-2016 [Internet]. Pokhara, Nepal: NAGRC, LI-BIRD and Bioversity International; 2017. Available from: https://www.bioversityinternational.org/fileadmin/user_upload/Released_and_promising_crop_varieties.pdf
4. Joshi BK. Rice gene pool for mid and high hills and its conservation in Nepal. In: Joshi BK, Joshi SL, Paudyal KP, editors. Agricultural Research for Enhancing Livelihood of Nepalese People [Internet]. Kathmandu: SAS-Nepal and NARC; 2004. p. 252–64. Available from: https://www.researchgate.net/publication/333654995_Rice_Gene_Pool_for_Mid_and_High_Hills_and_its_Conservation_in_Nepal
5. Joshi BK. Rice gene pool for Tarai and Inner Tarai areas of Nepal. Nepal Agric Res J. 2005;6:10–23.
6. Joshi BK. Rice and wheat gene pools in Nepal (1959-2002) [Internet]. Kathmandu Nepal: NAGRC, NARC; 2015. Available from: https://www.researchgate.net/publication/321309500_Rice_and_wheat_gene_pools_in_Nepal_1959-2002
7. Joshi BK, Acharya AK, Gauchan D, Singh D, Ghimire KH, Sthapit BR. Geographical indication: A tool for supporting on-farm conservation of crop landraces and for rural development. In: Joshi BK, KC HB, Acharya AK, eds), editors. Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal [Internet]. Dhulikhel, Kathmandu, Nepal: NAGRC, FDD, DoA and MoAD; 2017. p. 50–62. Available from: https://www.researchgate.net/publication/321670539_Geographical_indication_A_tool_for_supporting_on-farm_conservation_of_crop_landraces_and_for_rural_development
8. Gauchan D, Rijal D, Mudwari A, Shrestha K, Joshi M, S G, et al. Benefits from on-farm conservation of crop diversity: experience of Nepal's in situ agrobiodiversity conservation project. In: Gauchan, D., Sthapit BR, Jarvis DI, editors. Agrobiodiversity conservation on-farm: Nepal's contribution to a scientific basis for national policy recommendations [Internet]. Rome, Italy: IPGRI; 2003. p. 32–6. Available from: https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Agrobiodiversity_conservation_on-farm.Nepal_s__10_February_2002__Kathmandu__Nepal.pdf
9. Gauchan D, Chaudhary P, Smale M, Sthapit BR, Upadhaya MP, Jarvis DI. A participatory approach to analysing market based incentives for rice landraces: A case study of Bara, Central Terai, Nepal. In: On-farm management of agricultural biodiversity in Nepal Proceedings of a National Workshop [Internet]. Lumle, Nepal: NARC; 2003. p. 184–93. Available from: https://www.researchgate.net/publication/273144828_On-farm_management_of_agricultural_biodiversity_in_Nepal_Proceedings_of_a_National_Workshop_24-26_April_2001_Lumle_Nepal_NARC_LI-BIRD_and_IPGRI
10. N.A.R.C. Basmati rice in Tharu community, JamuhaniGau, Rupandehi, Nepal. Video documentary (in Tharu language [Internet]. Kathmandu, Nepal: Nepal Agricultural Research Council; 2020. Available from: https://www.youtube.com/watch?v=oacmV_T9KfU&t=108s
11. N.A.R.C. Tharu farmer's view on Basmati rice in BagahiGau, Rupandehi, Nepal [Internet]. Kathmandu, Nepal; 2020. Available from: https://www.youtube.com/watch?v=TjRSF_0kvBI&t=17s
12. N.A.R.C. Tharu farmer's view on Basmati rice in BagahiGau, Rupandehi, Nepal. Part II [Internet]. Kathmandu, Nepal; 2020. Available from: https://www.youtube.com/watch?v=Q6plhX_FWFQ
13. Joshi BK. Local germplasm of rice in Nepal: Diversity, characters and uses. In: Paudel MN, Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, editors. Rice Science and Technology in Nepal [Internet]. Khumaltar, Nepal: Crop Development Directorate (CDD), and Agronomy Society of Nepal (ASoN); 2017. p. 158–78. Available from: https://www.researchgate.net/publication/321329622_Local_germplasm_of_rice_in_Nepa_Diversity_characters_and_uses
14. Upreti HK. Distribution patterns of rice landraces in different agro-ecology zones of Nepal. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, Paudel MN, editors. Rice Science and Technology in Nepal [Internet]. Khumaltar, Kathmandu: CDD and Agronomy Society of Nepal (ASoN); 2017. p. 152–7. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
15. MoALD. Statistical information on Nepalese agriculture 2075/76. Kathmandu: MoALD; 2020.
16. E.C. 'BASMATI' EU No: PGI-IN-02425 – 18.7.2018. Eur Comm Off J Eur Union. 2020;63(C301):16–20.

17. Khush GS. Taxonomy and Origin of Rice. In: rices A, Singh RK, Singh, US, Khush GS, editors. Aromatic rices [Internet]. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd; 2000. p. 5–13. Available from: http://books.irri.org/8120414209_content.pdf
18. Pachauri V, Singh MK, Singh AK, Singh S, Shakeel NA, Singh VP, et al. Origin and Genetic Diversity of Aromatic Rice Varieties, Molecular Breeding and Chemical and Genetic Basis of Rice Aroma. J Plant Biochem Biotechnol. 2010;19(2):127–43.
19. Rijal DK, Kadayat KB, Joshi KD, Sthapit BR. Inventory of indigenous rainfed and aromatic rice landraces in Seti river valley Pokhara, Nepal [Internet]. Pokhara, Nepal: LI-BIRD; 1998. Available from: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/23370/113255.pdf?sequence=1
20. Joshi KD, Subedi M, Kadayat KB, Sthapit BR. Factors and processes behind the erosion of crop genetic diversity in Nepal. In: Pratap T, Sthapit B, editors. Managing agrobiodiversity [Internet]. ICIMOD and IPGRI; 1998. p. 183–97. Available from: https://www.researchgate.net/publication/282059405_Factors_and_Processes_behind_the_Erosion_of_Crop_Genetic_Diversity_in_Nepal
21. Joshi BK, Ojha P, Gauchan D, Ghimire KH, Bhandari B, HB KC. Nutritionally unique native crop landraces from mountain Nepal for geographical indication right. In: Traditional Crop Biodiversity for Mountain Food and Nutrition Security in Nepal. In: Gauchan D, Joshi BK, Bhandari B, Manandhar HK, Jarvis D, eds), editors. Tools and Research Results of the UNEP GEF Local Crop Project, Nepal NAGRC, LI-BIRD and the Alliance of Bioversity International and CIAT [Internet]. Kathmandu, Nepal: NAGRC, LI-BIRD and Bioversity International; 2020. p. 87–99. Available from: https://www.researchgate.net/publication/342145047_Nutritionally_Unique_Native_Crop_Landraces_from_Mountain_Nepal_for_Geographical_Indication_Right
22. Ojha P, Chaudhary O, Subedi U, Karki R, Dongol D. Milling, Nutritional, Physical and Cooking Properties of Four Basmati Rice Varieties. J Nepal Agric Res Counc. 2018;4(1):18–24.
23. Singh VP. The Basmati Rice of India. In: Singh RK, Singh US, Khush GS, editors. Aromatic rices [Internet]. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd; 2000. p. 135–51. Available from: http://books.irri.org/8120414209_content.pdf
24. Subbiah S. Reaping What They Sow: The Basmati Rice Controversy and Strategies for Protecting Traditional Knowledge. Boston Coll Int Comp Law Rev. 2004;27:529.
25. Islam MA, Anik TR, Hossain MM, Uddin MI, Ahmed MS. Genetic diversity analysis of some Bangladeshi aromatic rice (Oryza sativa L.) using simple sequence repeat markers (SSRM). Arch Agric Environ Sci. 2018;3(3):297-303,.
26. Bhattarai AN. A review of rice improvement in Kathmandu valley. Nepal J Agric. 1969;4:47–57.
27. Chataut RDP. Kata haraye ye dhaankajaatharu. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, Paudel MN, editors. Rice Science and Technology in Nepal [Internet]. Khumaltar, Nepal: Hariharbhawan and Agronomy Society of Nepal (ASoN; p. 41. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
28. Gin TP, Shahi BB. Performance of Aromatic Rice Varieties in Nepal. Proceeding of the 5th Rice Improvement Workshop. Bara, Nepal: NRIP; 1978.
29. Subedi KD, Paudel SS. Ayurvedma dhaanko mahatow. In: Paudel MN, Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, editors. Rice Science and Technology in Nepal [Internet]. Kathmandu Nepal: CDD and Agronomy Society of Nepal (ASoN); 2017. p. 34–7. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
30. Tripathi MP, Sthapit BR, Subedi LP, Sah SK, Gyawali S. Agro-morphological variation in Jhinuwa rice landraces (Oryza sativa L.) of Nepal. Genet Resour Crop Evol. 2013;60:2261–71.
31. Joshi B, Bhatta M. Joshi BK, MR Bhatta and KH Ghimire. 2013. Shali Dhan: Elite line of rice from Far West Nepal developed under the pre-breeding program in Genebank, Khumaltar. NARC Newsletter 20(4):5.
32. Tripathi AM. Kapilbastu jillaka dhanka purana sthaniya dhanko jaatharu. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, editors. Nepali language) In: Rice Science and Technology in Nepal [Internet]. Khumaltar, Kathmandu, Nepal: CDD and Agronomy Society of Nepal (ASoN); 2017. p. 819. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
33. Chauhan BK. Lopanmukh bhaudhakaalin kalanamak dhaan baali samraxan me jhod. Gorkhapatra. 2020;2077(9/15):9.
34. Kumar S, Mishra SB, Chaudhary RC. Breeding bauna kalanamak 102 as new aromatic variety of heritage rice from Uttar Pradesh. Int J Sci Environ Technol. 2018;7(5):1690–9.
35. Joshi KD, Sthapit BR, Vaidya A, Kadayat KB, Tuladhar JK, Subedi KD, et al. Report on Aromatic Rice Survey and RRA in Pokhara Valley of Nepal: Issues for Rice Research. LARC Work Pap. 1997;(95).
36. Rijal DK, Rana RB, Sherchand KK, Sthapit BR, Pandey YR, Adhikari N, et al. Findings of site selection in Kaski, Nepal. Nepal: NARC, LIBIRD and IPGRI; 1998.
37. Sherchand KK, Adhikari NP, Khatiwada SP, Shrivastav AC, Bajracharya J, Joshi KD, et al. Strengthening the scientific basis for in-situ conservation of agrobiodiversity: Findings of site selection in Bara. Nepal: NARC, LIBIRD and IPGRI; 1998.
38. Singh RK, Singh US, Khush GS, Rashmi Rohilla JPS, Singh G, Shekhar KS. Small and Medium Grained Aromatic Rices of India. In: Singh RK, Singh, US, Khush GS, editors. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd; 2000. p. 155–77. Available from: http://books.irri.org/8120414209_content.pdf
39. Tiwari RK, Baniya BK, Bajracharya J, Joshi BK, Joshi KD, Khatiwada SP, et al. On-farm characterization of rice landraces and population structure study of Jhinuwa in Begnas, Kaski. In: Subedi A, Joshi BK, Sthapit BR, Upadhaya MP, Baniya BK, editors. On-farm Management of Agricultural Biodiversity in Nepal [Internet]. Lumle Nepal, NARC: LIBIRD and IPGRI; 2003. p. 139–48. Available from: https://www.researchgate.net/publication/348591146_On_farm_characterization_of_rice_landraces_and_population_structure_of_Jhinuwa_in_Begnas_Kaski
40. Chaudhary B, Gyawali S, Joshi KD, Khatiwada SP, Shrestha K, Mudwodi A, et al. Participatory plant breeding in rice: Experience of National Rice Research Program, Hardinath, Nepal. In: Joshi BK, Joshi SL, Paudyal KP, eds), editors. Agricultural Research for Enhancing Livelihood of Nepalese People [Internet]. Kathmandu, Nepal: SAS-Nepal and NARC; 2004. p. 222–6. Available from: https://www.researchgate.net/publication/333640904_AGRICULTURAL_RESEARCH_FOR_ENHANCING_LIVELIHOOD_OF_NEPALESE_PEOPLE
41. F.A.O. Country Report on The State of the Nepal's Plant Genetic Resources for Food and Agriculture: Nepal [Internet]. Kathmandu: ABTRACO; 2008. Available from: http://www.fao.org/3/i1500e/Nepal.pdf
42. BK SB, Koirala KB, Ghimire KH, Prasai HK, Poudel RP, Poudel HP, et al. Consumers' preferences on different fine and aromatic rice varieties. In: Amgain RB, Manandhar S, Ghimire K, eds), Adhikari NP, Giri N, editors. Summer Crops Research in Nepal [Internet]. Nepal: NARC; 2012. p. 60–2. Available from: https://www.researchgate.net/publication/325653929_Consumers%27_Preferences_on_Different_Fine_and_Aromatic_Rice_Varieties
43. Koirala KB, Ghimire KH, Karki TB, SB BK, Bhattarai EM, Poudel RP, et al. Response of fine and aromatic rice varieties under different fertilizer levels. In: Giri YP, Manandhar HK, Khatiwada SP, Bajracharya J, Bhatta MR, Rai SK, et al., editors. Summer Crops Research in Nepal [Internet]. Nepal: NARC; 2012. p. 300–6. Available from: https://www.researchgate.net/publication/328335418_Response_of_Fine_and_Aromatic_Rice_Varieties_under_Different_Fertilizer_Levels
44. Koirala KB, Ghimire KH, SB BK, Bhattarai EM, Karki TB, Prasai HK, et al. Evaluation of fine and aromatic rice varieties under

different irrigation regimes. In: Koirala KB, Ghimire KH, Bishwokarma SB, editors. Promotion of fine and aromatic rice cultivation in western region of Nepal Final Technical Report [Internet]. Lumle, Kaski, Nepal: RARS, NARC; 2008. p. 26–41. Available from: https://www.researchgate.net/publication/328410356_Promotion_of_Fine_and_Aromatic_Rice_Cultivation_in_Western_Region_of_Nepal

45. Joshi BK, Bimb HP, Kansakar D, Ghimire E. Genetic relationship among Nepalese rice landraces and cultivars based on RAPD markers. Nepal J Biotechnol. 2012;2:16–25.
46. Adhikari SK. Purbeepahadi jillaharuma prachalanma rahyeka dhan Balika sthaniya jaatharu. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, Directorate CD, et al., editors. Rice Science and Technology in Nepal [Internet]. Khumaltar, Nepal: Hariharbhawan and Agronomy Society of Nepal (ASoN; 2017. p. 807. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
47. Bhatta MR, Joshi BK, Ghimire KH, Khanal M, Pokhrel T. Diversity and utilization status of cereals and pseudo-cereals in Nepal. In: Joshi BK, KC HB, Acharya AK, eds), editors. Conservation and Utilization of Agricultural Plant Genetic Resources in Nepal [Internet]. Dhulikhel, Kathmandu, Nepal: NAGRC, FDD, DoA and MoAD; 2017. p. 195–214. Available from: https://www.researchgate.net/publication/348049968_Conservation_and_Utilization_of_Agricultural_Plant_Genetic_Resources_in_Nepal_Proceedings_of_2nd_National_Workshop
48. Dhungana S. Grain quality evaluation of traditional aromatic rice varieties of Nepal. Eur Acad Res. 2017;IV(11):9864–73.
49. Ahuja SC, Ahuja U, Ahuja S. History and folklore of basmati rice. J Cereal Res. 2019;11(3):206–14.
50. Rana RB, Rijal DK, Gauchan D, Sthapit BR, Subedi A, Upadhyay MP, et al. In-situ crop conservation: Findings of agro -ecological, crop diversity and socio-economic baseline survey of Begnas ecosite. Kaski, Nepal: NARC, LIBIRD and IPGRI; 2000.
51. Shrestha P, Subedi A, Yadav RN, Yadav MN. Endangered rice local landraces in Central Tarai region of Nepal. Pokhara, Nepal: ADCS, LI-BIRD and USC; 2006.
52. Amatya G. Agrobiodiversity related farmer's based traditional knowledge register. Pokhara, Nepal: LI-BIRD; 2013.
53. Subodh K, Badal M. Characterization of available rice varieties through diversity block in Makwanpur and Sarlahi districts, Nepal. EC Agric. 2015;2(2):307–16.
54. Prodhan MZH. Effects of temperature on morphoagronomic performance, aroma gene expression and volatile profile of aromatic rice [Internet] [Doctoral dissertation]. [Malaysia]: University of Malaya, Kuala Lumpur; 2016. Available from: http://studentsrepo.um.edu.my/9519/5/zakaria.pdf
55. Ryan ML. Khanakhanubhayo (Have you eaten)? Traditional rice varieties, land tenure, and social structure in Nepal's midhills" [Internet]. [Ames, Iowa]: Iowa State University; 2018. Available from: https://lib.dr.iastate.edu/etd/16663
56. Ahuja SC, Ahuja U, Ahuja S. History and folklore of basmati rice. J Cereal Res. 2019;11(3):206–14.
57. Mandal A. A case study report on socio-religious and commercial values of basmati rice in Nepal. Rampur, Chitwan, Nepal; 2021.
58. N.A.P.A. Press Release on the Issue Related to Evidence on the Origin of Basmati Rice in Nepal. USA; 2021.
59. Gauchan D, Shrestha KH, Shrestha RN, Pandey N. Options for market linked rice research in Nepal. In: Proceedings of the 3rd National Workshop on Outreach Research [Internet]. Nepal: ORD, NARC; 1996. p. 250–5. Available from: http://elibrary.narc.gov.np/pages/view.php?ref=1295&k=
60. Gauchan D, Smale M, Chaudhary P. Market-based incentives for conserving diversity on farms: the case of rice landraces in Central Tarai, Nepal. Genet Resour Crop Evol. 2005;52:293–303.
61. Rana RB, Chaudhary P, Gauchan D, Khatiwada SP, Sthapit BR, Subedi A, et al. In-situ crop conservation: Findings of agro-ecological, crop diversity and socio-economic baseline survey of Kachorwa ecosite. Bara, Nepal: NARC, LIBIRD and IPGRI; 2000.
62. Joshi BK, Gorkhali NA, Pradhan N, Ghimire KH, Gotame TP, KC P, et al. Agrobiodiversity and its Conservation in Nepal. J Nepal Agric Res Counc. 2020;6:14–33.
63. Rana R, Gauchan D, Rijal D, Subedi A, Upadhyaya M, Sthapit B, et al. Factors influencing farmers' decisions on management of local diversity on-farm and their policy implications. In: Gauchan D, Sthapit BR, Jarvis DI, IPGRI, editors. Agrobiodiversity conservation on-farm: Nepal's contribution to a scientific basis for national policy recommendations [Internet]. Rome, Italy: IPGRI; 2003. p. 27–31. Available from: https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Agrobiodiversity_conservation_on-farm.Nepal_s__10_February_2002__Kathmandu__Nepal.pdf
64. Joshi KD, Upadhyay S, Chaudhary P, Shrestha S, Bhattarai K, Tripathi BP. The Rice Processing Industry in Nepal: Constraints and Opportunities. Agric Sci. 2020;11:1060–80.
65. C.D.D. Rice varietal mapping in Nepal: Implication for development and adoption [Internet]. Hariharbhawan, Lalitpur: CDD, DoA; 2015. Available from: http://doacrop.gov.np/downloadfile/Rice_Varietal_Mapping_1470895701_1512106555.pdf
66. S.Q.C.C. Notified and Denotified varieties of different crops till 2076-4-27 [Internet]. Kathmandu, Nepal: SQCC, MoALD; 2020. Available from: http://sqcc.gov.np/images/category/Notified_and_Denotified_Varieties_till_2076_04_07.pdf)
67. Joshi BK, Hay F, Sapkota S, Ebana K. Nepalese rice around the World. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, Paudel MN, editors. Rice Science and Technology in Nepal [Internet]. Khumaltar, Nepal: CDD and Agronomy Society of Nepal (ASoN); 2017. p. 221–40. Available from: https://www.researchgate.net/publication/321329311_Nepalese_rice_around_the_World
68. Joshi BK, Shrestha P, Gauchan D, Vernooy R, editors. Community Seed Banks in Nepal. In: 2nd National Workshop Proceedings, 3-5 May 2018 [Internet]. Kathmandu Nepal; NAGRC: LI-BIRD and Bioversity International; 2018. p. 154–208. Available from: http://himalayancrops.org/project/community-seed-banks-in-nepal-2nd-national-workshop-proceedings/
69. Badal M, Chaudhary SN, Subedi B, Tharu CS. Community Seed Bank Implementation Approach of Action Aid Nepal. In: Joshi BK, Shrestha P, Gauchan D, Vernooy R, editors. Community Seed Banks in Nepal 2nd National Workshop Proceedings [Internet]. Kathmandu Nepal: NAGRC, LI-BIRD and Bioversity International; 2018. p. 95–105. Available from: http://himalayancrops.org/project/community-seed-banks-in-nepal-2nd-national-workshop-proceedings/
70. Shrestha DK, Paudel IP, Dhakal R, Rasaili S. Conserved local rice landraces in Community Seed Bank, Kachorwa, Bara [Internet]. Pokhara, Nepal: LI-BIRD; 2017. Available from: http://www.libird.org/app/publication/view.aspx?record_id=254&origin=results&QS=QS&sortfld_221=Date&reversesearch=true&top_parent=221
71. Ghimire KH, Sah RP, Bhandari HS, Thapa B. Collection and characterization of local and exotic fine-aromatic germplasm. In: Gautam AK, Akhtar T, Chaudhary B, Gaire J, Bhatta KR, editors. Rice Research in Nepal Proc 24th Summer Crops Workshop [Internet]. Kathmandu, Nepal: NARC; 2004. p. 408–11. Available from: http://elibrary.narc.gov.np/pages/view.php?ref=1130&k=
72. Ahuja U, Ahuja SC, Thakrar R, Rani NS. Scented rices of India. Asian Agri-Hist. 2008;12(4):267–83.
73. Bisne R, Sarawgi AK. Agro-morphological and quality characterization of badshah bhog group from aromatic rice germplasm of Chhattisgarh. Bangladesh J Agric Res. 2008;33(3):479–92.
74. Siddiq EA, Vemireddy LR, Nagaraju J. Basmati rices: Genetics, breeding and trade. Agric Res. 2012;1:25–36.
75. Ashfaq M, Haider MS, Saleem I, Ali M, Ali A, Chohan SA. Basmati – Rice a class apart (A review). J Rice Res. 2015;3:156.
76. Choi JY, Lye ZN, Groen SC. Nanopore sequencing-based genome assembly and evolutionary genomics of circum-basmati rice. Genome Biol. 2020;21:21.

77. Civáň P, Ali S, Batista-Navarro R, Drosou K, Ihejieto C, Chakraborty D, et al. Origin of the aromatic group of cultivated rice (Oryza sativa L.) traced to the Indian Subcontinent. Genome Biol Evol. 2019;11(3):832–43.
78. Joshi BK, Shrestha N, Pokhrel R, Chaudhary R. Molecular characterization, DNA fingerprinting and genetic diversity analysis of Nepalese rice landraces using SSR markers. NARC, Khumaltar, Kathmandu, Nepal; 2020.
79. Joshi KD, Tiwari RK, Sthapit BR. Diversity assessment of Jetho Budho rice landrace Kaski. In: On-farm management of agricultural biodiversity in Nepal Proceedings of a National Workshop [Internet]. Lumle, Nepal: NARC; 2003. p. 262–5. Available from: https://www.researchgate.net/publication/273144828_On-farm_management_of_agricultural_biodiversity_in_Nepal_Proceedings_of_a_National_Workshop_24-26_April_2001_Lumle_Nepal_NARC_LI-BIRD_and_IPGRI
80. Joshi KD, Chaudhary P, Yadav RB, Sthapit BR. Diversity assessment for the enhancement of selected rice landraces Kariya Kamodh and Lalka Basmati at Kachorwa, Bara. In: On-farm management of agricultural biodiversity in Nepal Proceedings of a National Workshop [Internet]. Nepal. NARC: Lumle; 2003. p. 254–61. Available from: https://www.researchgate.net/publication/273144828_On-farm_management_of_agricultural_biodiversity_in_Nepal_Proceedings_of_a_National_Workshop_24-26_April_2001_Lumle_Nepal_NARC_LI-BIRD_and_IPGRI
81. Sah RP, Akhtar T, Bhandari HS, Thapa B, Ghimire KH. Diallel analysis for estimation of combining ability and gene action in fine-aromatic rice. In: Gautam AK, Akhtar T, Chaudhary B, Gaire J, Bhatta KR, editors. Rice Research in Nepal [Internet]. Kathmandu: NARC; 2004. p. 105–13. Available from: http://elibrary.narc.gov.np/pages/view.php?ref=356&k=
82. Thakur GC, Sah SN, Akhtar T, Ghimire KH, Khatiwada SP, Hamal G, et al. Varietal investigation activities for fine grain and aromatic rice of Nepal. In: Rai SK, Paneru RB, Joshi BK, Ghimire KH, Amgain RB, Manandhar S, et al., editors. Summer Crops Research in Nepal [Internet]. Kathmandu, Nepal: NARC; 2012. p. 144–51. Available from: http://elibrary.narc.gov.np/pages/view.php?ref=3209&k=
83. Joshi BK, HB KC, Tiwari RK, Shrestha P, Amagain R, Upadhyay MP. Varietal richness of agricultural crop species and farmers' preferred traits over space and time in Nepal. Bot Oreintalis J Plant Sci. 2005;5:69–74.
84. Bajracharya J, Rana RB, Gauchan D, Sthapit BR, Jarvis DI, Witcombe JR. Rice landrace diversity in Nepal. Socio-economic and ecological factors determining rice landrace diversity in three agro-ecozones of Nepal based on farm surveys. Genet Resour Crop Evol. 2010;57(7):1013–22.
85. Paudel B, Maharjan S. K, B RR, Shrestha A, Shrestha P, Basnet A, et al. Findings of Baseline Survey on Socio-economic and Agricultural Biodiversity of Western Terai Landscape Project of Nepal [Internet]. Pokhara, Nepal: Local Initiatives for Biodiversity, Research and Development; 2008. Available from: https://www.researchgate.net/publication/274700362_Findings_of_Baseline_survey_on_socioeconomic_and_agricultural_biodiversity
86. Ghimire KH, Koirala KB, SB BK, Prasai HK, Poudel R, Poudel HP. Characterization of local fine and aromatic rice varieties and status of prevailing rice varieties in the project sites. In: Koirala KB, Ghimire KH, Bishwokarma SB, editors. Promotion of fine and aromatic rice cultivation in western region of Nepal Final Technical Report [Internet]. Lumle, Kaski, Nepal; 2008. p. 4–7. Available from: DOI: https://www.researchgate.net/publication/328410356_Promotion_of_Fine_and_Aromatic_Rice_Cultivation_in_Western_Region_of_Nepal
87. Gurung R, Dhakal R, Pudasaini N, Paneru PB, Pant S, Adhikari AR, et al. Catalog of Traditional Crop Landraces of Mountain Agriculture in Nepal [Internet]. Pokhara; Nepal: NARC, LI-BIRD, Bioversity International; 2019. Available from: http://himalayancrops.org/project/catalogue-of-traditional-mountain-crop-landraces-in-nepal/
88. Yadaw R, Chaudhary P, Bajracharya J, Rijal D, Khatiwada S, Tiwari RK, et al. Agro-morphological diversity in rice landraces of Bara and Kaski eco-sites. In: Subedi A, Joshi BK, Sthapit BR, Upadhaya MP, Baniya BK, editors. On-farm Management of Agricultural Biodiversity in Nepal [Internet]. Lumle, Kaski, Nepal: NARC, LIBIRD and IPGRI; 2003. p. 42–7. Available from: https://www.researchgate.net/publication/348116250_On-farm_management_of_agricultural_biodiversity_in_Nepal
89. Yadav H. Madhya tarai xetrama prachalit dhanka sthaniya jaatharu tatha tinka jaatiya biseshta. In: Bhandari DR, Khanal MP, Joshi BK, Acharya P, Ghimire KH, editors. Rice Science and Technology in Nepal [Internet]. Kathmandu, Nepal: CDD and Agronomy Society of Nepal (ASoN); 2017. p. 808. Available from: http://www.doacrop.gov.np/downloadfile/Rice_science_and_technology_1512106674.pdf
90. Joshi BK, Ghimire KH, Shrestha SK, editors. AFACI Pan Asia Project (IMPGR): Exploration, regeneration and conservation of endangered cereals, grain legumes from Central Mid and High Hills of Nepal. Khumaltar, Kathmandu, Nepal: NAGRC and AFACI; 2014.
91. Joshi BK, Bhatta MR, Ghimire KH. Shali Dhan: Elite line of rice from Far West Nepal developed under the pre-breeding program in Genebank, Khumaltar. NARC Newsl. 2013;20(4).
92. Bimb HP, Sah RP, Karn NL. Isozyme variations in fine and aromatic rice genotypes. Nepal Agric Res J. 2004;5:59–64.
93. Glaszmann JC. Isozymes and classification of Asian rice varieties. Theor Appl Genet. 1987;74(1):21–30.
94. Kishor DS, Seo J, Chin JH, Koh H-J. Evaluation of whole-genome sequence, genetic diversity, and agronomic traits of basmati rice (Oryza sativa L. Front Genet [Internet]. 2020;11(86). Available from: https://www.frontiersin.org/articles/10.3389/fgene.2020.00086/full