Conservation Science

Translating Knowledge into Actions

Wheat gene pool and its conservation in Nepal

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Summary

Aim This paper explores diversity of wheat gene pool present in the Nepalese bread wheat cultivars and landraces, and discusses their conservation initiatives.

Location Nepal.

Material and Methods This study is carried out using an extensive literature survey on distribution of landraces and wild relatives of wheat in Nepal.

Key findings The results showed that there were 35 improved wheat cultivars, 540 landraces and 10 wild relatives of wheat in Nepal. Mexico, India and Nepal were the countries of origin for 35 cultivars. A total of 89 ancestors of wheat originated from 22 countries were used to develop 35 cultivars. The highest number of ancestors was from India. Ancestors of both aestivum and durum species having winter, spring and intermediate growth habit indicated that these species were of wide gene pool. The genetic erosion in wheat gene pool is the main conservation challenge of landraces due to introduction of improved varieties.

Conservation implications Genetic diversity of wheat is indispensible for sustainable wheat production. Therefore, on-farm and ex-situ conservations of cultivars, landraces and wild varieties of wheat and their use in breeding programs are necessary for maintaining existing genetic diversity.

Keywords ancestor, conservation, landrace, Nepalese wheat cultivar, wheat gene pool

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Introduction

In Nepal, wheat is said to have been grown since time immemorial particularly in Far and Mid Western Hills of Nepal. Mudwari (1999) reported many landraces and 10 wild relatives of wheat. Several exotic varieties are introduced with support of CIMMYT (International Maize and Wheat Improvement Cetner) and USAID (United States Agency of International Development) (NARC 1997). In Nepal, National Wheat Development Program was established in 1972 to organize the research and development works on wheat as a commodity crop. Improved wheat cultivars have been playing an important role in food security in Nepal, and currently more than 90% of the wheat area is covered by improved wheat cultivars (Bhatta et al. 2000). Wheat is mainly used for bread and biscuits. It is becoming more important part of the Nepal's economy.

Maintaining genetic diversity of crops is necessary to derive different transgenic segregants suitable for different agro-ecology to meet the demands of farmers. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the development of varieties and existing landraces. The level of genetic variation present in gene pools of the most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza and Sorrells 1989), soybean (Cox et al. 1985a), winter wheat (Cox et al. 1985b), rice (Dilday 1990) and barley (Martin et al. 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. Crosses between winter and spring wheat gene pools are far more common and offer a new source of diversity (CIMMYT 1987). Nepalese wheat cultivars possess a great diversity because many ancestral genotypes are used to develop wheat cultivars (Joshi et al. 2004). Diversity of wheat considering ancestors of cultivars and landraces should be assessed for effective conservation and utilization of wheat gene pools.

Materails and methods

Study area

The study area covers most parts of Nepal from lowlands to high mountains. Although Nepal shares slightly less than 0.1% of the global land mass, but it contains a high diversity of wild flora and fauna including agrobiodiversity. In Nepal, people cultivate wheat in all the physiographic regions but the variety of wheat is different according to the climate. Physiographic regions describe the physical geography in terms of landform, climate, altitude and soils. Such division provides an important baseline for ecological studies of the Himalayan biodiversity. Physiographic division of Nepal is based on the three main mountain ranges- Siwalik, Mahabharat and Himalaya, which have average altitudes increasing from south to north. These ranges create specialized regions that enhance agrobiodiveristy.

Data collection and analysis

The major sources of data in this study include published literatures. Literature related to wheat exploration, improved cultivars and Nepalese landraces (Table 1) were reviewed. Two sites, National Wheat Research Program (NWRP), Bhairawa and Genetic Seed House of Agriculture Botany Division (ABD), Khumaltar were visited. These two sites house many wheat landraces. Frequencies of wheat accessions collected from different districts and conserved in Genetic Seed House were computed and presented in **Table 2.** We examined the pedigrees of 35 cultivars released from 1960 to 2001 (Table 3). Most of the cultivars were introduced either from CIMMYT, Mexico or India. The pedigrees of all bread wheat cultivars were traced back to their ancestors that had no known relationship each other. The source of pedigrees and release dates for cultivars were Jain (1994), NARC (1997), Bland (2001), Skovmand et al. (1997) and Skovmand et al. (2000). Countries from where the genes introduced in Nepal were located in world map (**Figure 2**) based on the origin of ancestors of improved wheat cultivars.

Results

Eighteen exploration programs carried out in different parts of Nepal showed that there were 64 landraces (now conserved at National Agriculture Genetic Resources Center in ABD). The distribution of these landraces and their cultivating area in different parts of Nepal is presented in Table 1. The data showed that wheat landraces were distributed mainly between 720 to 3353 m. Based on the collected data, landraces distributions were plotted in the country map. The diversity of wheat was higher in the far western region as compared to other regions of country (**Figure 1**).

Figure 1: Distribution of Nepalese wheat landraces in Nepal (number of red dots directly proportional to the diversity of wheat)

Table 1: Different Nepalese wheat landraces and their cultivating area (Gupta et al. 2000)

SN	Landrace	District	Location	Altitude (m)
1.	Badi gahun	Bajura	Gadukhati-9	1768
2.	Bangali gahun	Kalikot	Jubitha-7, Jubitha	1792
3.	Bartole gahun	Baitadi	Patan	1372
4.	Bhabri gahun	Mugu	Srinagar-5, Chaina	1960
5.	Bhagere gahun	Baglung	Bhimpokhara	1565
6.	Bhartole gahun	Baitadi	Gokuleswor-1, Kalchunde	720
7.	Bhote gahun	Solukhumbu	Salleri	2408
8.	Bhugari gahu	Bajura	Atichaul-1	1981
9.	Bikase gahun	Darchula	Gokuleswor-3, Gokuleswor	750
10.	Bikasi seto gahun	Sallyan	Dandagaon	1200
11.	Bugoti	Bajura	Dogdi-6	1829
12.	Bungoli	Bajhang	Kalukheti-8	1737
13.	Chamdi gahun	Bajura	Gadukhati-9	1768
14.	Dabde gahun	Jumla	Patrasi-7, Shelagarhigaon	2713
15.	Dabdi gahun	Dandeldhura	Joishina	1585
16.	Dabdikhane gahun	Dandeldhura	Matargaon	
17.	Dalkhane gahun	Kalikot	Mahadev-7, Sarkivada	1980
18.	Dapche gahun	Dandeldhura	Bhel	1585
19.	Daudi	Baitadi	Patan	1372
20.	Daudi gahun	Baitadi	Shidheswor-8, Amarkholi	2070
21.	Dhaule gahun	Baitadi	Gokuleswor-1, Kalchunde	720
22.	Dho	Mustang	Kagbeni	2697
23.	Dho gahun	Mustang	Jharkot	3353
24.	Dhu	Mustang	Khinga	3216
25.	Dolkhe gahun	Khotang	Khalde	1402
26.	Dudhe murilo	Rukum	Vulma	823
27.	Gahun	Baglung	Dobira	1010
28.	Gaile gahun	Bajura	Gadukhati-9	1768
29.	Geru gahun	Mugu	Pina-5, Balagaon	2035
30.	Gharelu gahun	Dandeldhura	Manara	1158
31.	Hansa gahun	Myagdi	Benibagar	792
32.	Jhirke	Bajhang	Majhigaon-8	1585
33.	Jhuse gahun	Sallyan	Dandagaon	1100
34.	Jhuserato gahun	Kalikot	Mahadev-7, Sarkivada	1980
35.	Keuma gahun	Solukhumbu	Chhulembu	2195
36.	Lal gahun	Kanchanpur	Mahendra nagar-19	
37.	Lalitpur local			
38.	Lerarato gahun	Sallyan	Dandagaon	1200
39.	Lereseto gahun	Sallyan	Tharmare	1160
40.	Local			
41.	Local gahun	Jumla	Birat-9, Ludku	2390
42.	Lunthung gahun	Taplejung	Lelep-5, Lunthum	1800
43.	Mude gahun	Dandeldhura	Bhandare	1530
44.	Mudlo gahun	Baglung	Gitapatha	1094
45.	Mudule gahun	Arghakhanchi	Dhikura-2, Gairakot	1200
46.	Mudulo gahun	Myagdi	Dhode	747
47.	Murala gahun	Rolpa	Khumil	1500
48.	Murulo rato gahun	Jajarkot	Gaganekhola	2775
49.	Nano gahun	Dandeldhura	Ghatal	1768
50.	Paude gahun	Baitadi	Vasling-3, Gwane	2040
51.	Pawai	Bajura	Kolti	2000
52.	Peta gahun	Solukhumbu	Chhulembu	2195

Contd.

Table 1: Different Nepalese wheat landraces and their cultivating area (Contd.)

SN	Landrace	District	Location	Altitude (m)
53.	Rani gahu	Bajhang	Majhigaon-8	1585
54.	Rato gahun	Jajarkot	Risang	2850
55.	Rato nal	Baitadi	Patan	1372
56.	Rato nale	Baitadi	Patan-1	1372
57.	Rupali gahun	Dandeldhura	Amargadhi-2, Dotighatal	1750
58.	Sano gahun		Suda	
59.	Sate gahun	Taplejung	Nankholyang-5, Myakha	900
60.	Seto gahun	Rukum	Khara	
61.	Talak gahu		Mahendranagar	
62.	Tarigaire	Bajura	Gadukhati-9	1768
63.	Those gahun	Bajura	Gadukhati-9	1768
64.	Thulo ghumche	Jajarkot	Dandagaon	2750

In Khumaltar, samples of wheat landraces from 29 districts of Nepal were stored safely (**Table 2**). The highest number of wheat accessions was collected from Dandeldhura district (3.59% of total accessions) followed by Baitadi (3.33%), Bajura and Baglung districts. Collection sites of 236 accessions are still unknown. The study showed that Dandeldhura, Baitadi, Bajura, Baglung and Achham districts may be rich in wheat landraces diversity.

A total of 89 ancestors originated from 22 different countries were used to develop 35 cultivars. Mexico, India and Nepal are the origin countries for 35 cultivars (**Figure 2**). The use of 89 ancestors from 22 different countries represented the high diversity that built in 35 Nepalese wheat cultivars. The origins of 9 ancestors were still unknown. Ancestors were with different growth habits e.g. spring (57.31%) and winter (13.48%). Growth habits of 29.21% ancestors and species type of 17.98% ancestors are not known. Among the ancestors, there were 76.40% of *aestivum* and 5.62% of *durum* species.

Discussion

The land in Nepal has the largest variations in term of altitude in the world. Three types of land management systems– Bari (land attached with house), Khet (land not attached with house), and flat (land usually larger in size and far from house) with good soil depths—are used for wheat production in Nepal which indicates the diverse wheat genotypes adapted to different production environments. Due to the varied agro-ecological diversity of the country, it is possible to plant same cultivar in both winter and summer seasons. Nepal is not original home for wheat but under the CGIAR system, Nepal has received a lot of wheat genotypes. In 1965, the Department of Agriculture launched a *Grow more wheat campaign* with the introduction of Mexican semi dwarf wheat resulted in a rapid expansion in wheat area and production.

Table 2: Frequency and total accessions of wheat landraces collected from different districts of Nepal and conserved in Khumaltar. Accession (n), Frequency (F- in %)

SN	District	n	F
1	Achham	11	2.82
2	Arghakhanchi	1	0.26
3	Baglung	12	3.08
4	Baitadi	13	3.33
5	Bajhang	6	1.54
6	Bajura	12	3.08
7	Dandeldhura	14	3.59
8	Darchula	4	1.03
9	Doti	6	1.54
10	Gorkha	1	0.26
11	Gulmi	2	0.51
12	Jajarkot	5	1.28
13	Jumla	6	1.54
14	Kalikot	5	1.28
15	Kanchanpur	1	0.26
16	Kaski	1	0.26
17	Khotang	3	0.77
18	Manang	5	1.28
19	Mugu	5	1.28
20	Mustang	9	2.31
21	Myagdi	6	1.54
22	Nawalparasi	1	0.26
23	Panchthar	1	0.26
24	Pyuthan	2	0.51
25	Rolpa	2	0.51
26	Rukum	6	1.54
27	Sallyan	5	1.28
28	Solukhumbu	7	1.79
29	Taplejung	2	0.51
30	Unknown	236	60.51

Many crop exploration programs were carried out in different parts of Nepal to collect different landraces of crops for conservation. There were different

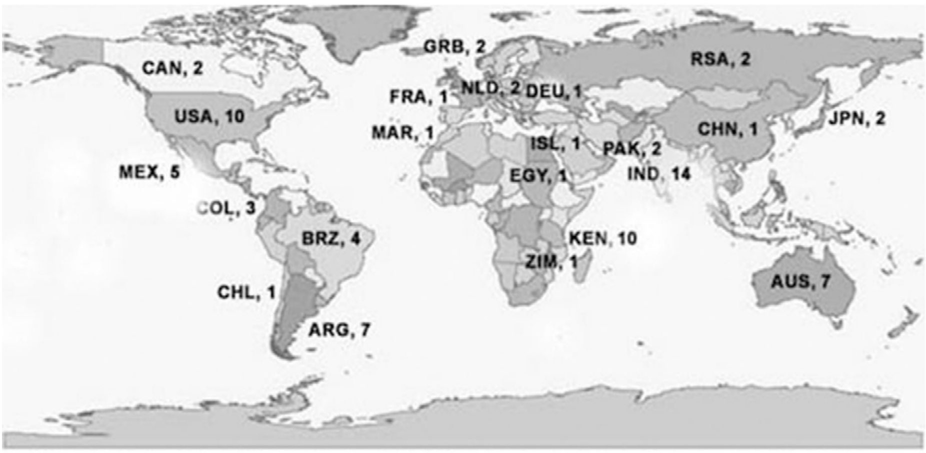

Figure 2: Countries where the ancestors of Nepalese improved wheat cultivars were originated (value after country code indicates total ancestors, origin of 9 ancestors are unknown).

landraces of wheat in different altitudes. There may be many landraces that are genetically same but differed only by name or vice versa. ABD has 390 accessions of wheat landraces collected from all over the country (now these collections has been shifted to National Agriculture Genetic Resources Center, NAGRC). These are conserved in ex-situ basis in Khumaltar. Due to agro-ecological differences, Nepalese genotypes might contain unique genes. Dutch scientists who collected in around 1981, wheat in remote part of the Himalayan in Nepal has found material that is new and considerably different from germplasm already in genebank anywhere in the world (Hawkes 1981). These genes if conserved properly could have significant role in fulfilling wheat grain demand in Nepal.

Nepal has many locally adapted wheat but many of them have not been used in breeding program. Such trends may lead to genetic erosion. However, in the recent years NWRP has maintained 150 landraces, and NAGRC has 390 accessions of wheat. There may be duplicate accessions in these two places. Removing duplicate accessions and adding new one should be a focus in wheat conservation program. Characterization, evaluation and utilization of these landraces in breeding program by NWRP, ABD and NAGRC could certainly enhance the wheat genes pool conservation. Landraces are mostly found in western regions and only few locations of central and eastern regions of Nepal (NARC 1997). There are many important landraces in western region. For example, Dabad Khani is most popular local wheat suitable in maize based cropping pattern in the western region of Nepal. Distribution pattern could help to locate diverse wheat areas and to implement in-situ, on-farm conservation as well as exploration program. Characterization and improvement of these landraces are necessary for long-term conservation and utilization. Due to the expansion of modern varieties, these landraces are under threats to extinction. Extensive survey and duplication study of accessions are necessary to control genetic erosions and conservation cost.

Many of these landraces are still being grown by farmers and are the mixtures of white and brown colored spike, amber and red colored kernels, awned and awnless characters. These landraces have a wide range of natural adaptation to withstand varied abiotic (e.g., withstand severe drought stress) and biotic (e.g., high protein content, high tillering ability, longer seed dormancy) conditions. Most of these landraces are pure spring bread wheat types and some other landraces available in the northern high mountain area bordering Tibet are winter growth type (CIMMYT 1987). In addition to these, some diploid species have also been reported in the northern high mountains. These landraces are generally grown under marginal lands in the rainfed and low fertility conditions (Gupta et al. 2000).

Thirty-five improved bread wheat varieties suitable to hills, plains and western regions of Nepal had been released during the period from 1960 to 2001. More numbers of crosses involving many parental lines in cultivars like Annapurna2, Annapurna4, Bhrikuti, LR64, RR21, NP884 and NP804 indicate the conservation efforts to collect valued genes in single genotypes. Lerma52 is the first improved cereal variety released in 1960 in Nepal (Bland 2001). Shuttling of generation lines during the off-season has also helped to develop more wheat cultivars within short period of time. Two cultivars are recommended for both areas i.e. plain and hill. In Nepal, four cultivars had been originated whereas maximum number of cultivars was originated in Mexico. Ancestors of both aestivum and durum species having winter, spring and intermediate growth habit indicate the species with diverse genes.

Currently, Nepal has cultivars of wheat having genes from 89 internationally valued wheat landraces. Wheat genes from many countries were introduced in Nepal through improved cultivars (Figure 2). Maximum

Table 3: Improved bread wheat varieties released from 1960 to 2001 in Nepal

SN	Variety	Pedigree	Origin	Year released	Area of adaptation
1.	Achyut	CPAN168/HD2204	India	1997	Plains
2.	Annapurna1	KVZ/BUHO//KAL/BB	Mexico	1988	Hills
3.	Annapurna2	NAPO/TOB//8156/3/KAL /BB	India	1988	Hills
4.	Annapurna3	KVZ/BUHO//KAL/BB	Mexico	1991	Hills
5.	Annapurna4	KVZ/3/CC/INIA//CNO/ ELGAU/4/SN64	Mexico	1994	Hills
6.	Bhrikuti	CMT/COC75/3/PLO// FURY/ANA	Mexico	1994	Plains
7.	Bhairawa Line1022	PVN/ALD	Nepal	1991	Western Terai
8.	Bhairawa Line1135	QTZ/TAN	Nepal	1994	Plains
9.	Bhairawa Line1473	NL297/NL352	Nepal	1999	Plain & Hills
10.	Hybrid Delhi1982	E5557/HD845	India	1975	Western Plains
11.	Kalyansona	PJ/GB55	Mexico	1968	Plains
12.	Kanti	LIRA/FFN//VEE	Mexico	1997	Hills
13.	Kenya291	NA†	Kenya	1962	Hills
14.	Lerma52	MTA/K324	Mexico	1960	Hills
15.	Lerma Rojo64	Y50/N10B//L52/3/ 2*LR	Mexico	1967	Hills
16.	Lumbini	E4871/PJ	India	1981	Plains
17.	Nepal Line251	WH147/HD2160 //2*WH147	India	1988	Plains
18.	Nepal Line297	HD2137/HD2186 //HD2160	India	1985	Plains
19.	Nepal Line30	HD832/BB	India	1975	Western Plains
20.	New Pusa799	NP 792	India	1962	Hills
21.	New Pusa809	DO/C518//SPP/NP114 /3/WIS245	India	1962	Hills
22.	New Pusa835	NP760/RN	India	1962	Plains
23.	New Pusa852	KF/2*NP761	India	1962	Plains
24.	New Pusa884	KC6042/GUL//PLT/3/ K58/N/4/ NP755	India	NA†	Plains
25.	Pasang Lhamu	PGO/SERI	Mexico	1997	Hills
26.	Pitic62	YT54/N10B 26.1C	Mexico	1967	Hills
27.	Rohini	PRL/TONI//CHIL	Nepal	1997	Plains
28.	Rust Resistant21	II53.388/AN/3/YT54/ N10B/3/LR/4/B4946.A .4.18.2.IY/Y53//3*Y50	Mexico	1971	Hills & Plains
29.	S331	LR64/HUAR	Mexico	1971	Hills & Plains
30.	Siddhartha	HD2092/HD1962// E4870/3/K65	India	1983	Plains
31.	Sonora64	YT54/N10B//2*Y54	Mexico	1967	Hills
32.	Triveni	HD1963/HD1931	India	1982	Plains
33.	Uttar Pradesh262	S 308/BAJIO 66	India	1978	Plains
34.	Vaskar	TZPP/PL//7C	Mexico	1983	Midwestern Plains
35.	Vinayak	LC55	India	1983	Plains

† NA, Not available.

ancestors were from India followed by USA and Kenya. Involvement of ancestors from 22 countries indicates the introduction of genes adapted to different geographic locations of Nepal. Eventhough contributions of Nepalese wheat landraces in the world are not known, world contribution is recognized in wheat development in Nepal. A single landrace of each of eight countries have been used in developing wheat cultivars probably because of having valued genes with them. It can be concluded that breeders can develop better varieties by reshuffling the genes from these wide collections.

Conclusions and Conservation Implications

Wheat diversity in Nepal is high due to availability of various cultivated landraces of spring and winter type, wild relatives and diploid species (Bland 2001). Nepal being proximal to the secondary source of origin of wheat, might harbor many species of wheat relatives (e.g., one species of Aegiolopes and nine species of Agropyron recorded till present). Gene pools from these landraces along with international gene pool have resulted in developing high yielding cultivars with wide adaptability. Developing cultivars possessing desired period of maturity, height and yield is seemed possible using these genes pool. Therefore, such diversity should be conserved properly in the genebanks.

Despite high yielding attributes of improved cultivars compared to those of local types, improved varieties were found to be more susceptible to diseases and lodging (Shrestha 1976). There are many examples of improved varieties gaining popularity within a short period of time but later become susceptible to biotic stresses. Such trend was not reported in landraces. It is indicated that improved cultivars represent a wide range of variation for different areas of origin and adaptation. The genetic erosion occurs due to replacement of the landraces and local varieties by improved varieties. Therefore, on-farm and ex-situ conservations are necessary for maintaining the available genetic diversity. These approaches should be treated as complementary. Government, semi-governmental and private agencies should take action to conserve and utilize wheat genetic variations.

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Biography

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