



Present Status and Upcoming Research Strategies for Nepal's Winter Legume Crops

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Grain legume cultivation is the fundamental part of the Nepalese agriculture production systems, as these crops can be grown in a wide range of land from fertile to degraded or marginal soils, and also because of the *Dal-Bhat-Tarkari* eating habits of its populace. These crops occupied about 11% of the country's total cultivated land, and fourth in the area and production after rice, maize, and wheat. Grain legume crops are also called 'poor mans' meat', and these crops have a significant role in increasing cropping intensity, crop diversification, soil improvement, and food and nutritional security. Among the grain legume crops, lentil (*Lens culinaris* Medikus), chickpea (*Cicer arietinum* L.; *Cicer kabulium*.), kidney bean (*Phaseolus vulgaris* L.), grasspea (*Lathyrus sativus* L.), fababean (*Vicia faba* L.), and field pea (*Pisum sativum* L.) are the main legume crops for the winter season in Nepal. The Grain Legume Research Program (GLRP), Khajura has released and registered fourteen varieties of lentil, seven varieties of chickpea, and one variety of kidney bean for the cultivation in different agro-ecological domains with their improved cultivation practices, *i.e.*, agronomic and disease and pest managements.

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1. INTRODUCTION

Grain legumes are the fundamental part of the Nepalese agriculture production systems, as the source of protein, income and soil fertility improvement. These crops can be grown in a wide range of land from fertile to degraded or marginal soils and are the most important crops for the small and marginal farmers (Gowda et al., 2000; Schulz et al., 1999). These crops occupied about 11% of the country's total cultivated land, and fourth in the area and production after rice, maize, and wheat (Darai et al., 2021; Neupane et al., 2021). Grain legume crops are also called 'the poor mans'food meat', and these crops have a significant role in increasing cropping intensity, crop diversification, and food and nutritional security (Pokhrel & Poudel, 2024; Neupane & Shrestha, 2015; Bista et al., 2013).

Climate change induced vulnerabilities poses a significant threat to global food and nutritional security. In response, there is an urgent need to identify resilient crops capable of mitigating these threats. Grain legumes stand out as a promising group of crops for the future due to their adaptability and nutritional richness (Dutta et al., 2022). Grain legumes are a valuable gift of nature, offering high protein content (16 to 50 percent), essential nutrients, dietary fiber (10 to 23 percent), and various vitamins (Dutta et al., 2022). Among the grain legume crops, lentil (*Lens culinaris* Medikus), chickpea (*Cicer arietinum* L.; *Cicer kabulium*.), kidney bean/rajma (*Phaseolus vulgaris* L.), grasspea (*Lathyrus sativus* L.), fababean (*Vicia faba* L.), and field pea (*Pisum sativum* L.) are the main legume crops for the winter season in Nepal (Pokhrel et al., 2018).

The Grain Legume Research Program (GLRP), Khajura is the only one research body under the Nepal Agricultural Research Council (NARC) of the country, which has mainly focused on improving food security, livelihood and resource conservation through the development of improved varieties, generating farmer's friendly technologies and providing consultative services (Maskey et al., 2001; Sharma, 2015). The GLRP has released and registered fourteen varieties of lentil, seven varieties of chickpea, and one variety of kidney bean for different agro-ecological domains with their improved cultivation practices, *i.e.*, agronomic and disease and pest management, but this program has not

yet released any variety of grasspea, fababean, and field pea due to the human resources constraint (Pokhrel & Poudel, 2024). This coordinated paper certainly helps update the research status and strategies on winter grain legumes for all concerned researchers, extension personnel, students, and finally to the farmers.

2. AREA, PRODUCTION AND YIELD OF WINTER GRAIN LEGUMES

The lentil is the first important winter legume crop that is grown in 198,454 ha with the production and productivity of 252,283 t and 1.3 t/ha, respectively (MoALD, 2023). Similarly, chickpea and grasspea have grown in an area of about 10,600 ha, which have produced 12,143 t separately in the country. Among the grain legume crops, the lentil shares 59% of the total cultivated area, where chickpea and grasspea share about 3% of the cultivated area of grain legumes in the country. Not much data on the area and production of kidney beans are available in the country. Based on the MoALD (2023), the beans are grown in an area of 33,832 ha, which produces 40,260 t with a productivity of 1.2 t/ha.

There is an increasing trend in area, production and yield of lentil, chickpea and grasspea over 20 years in the country. The area of lentil, chickpea and grasspea has increased by 6, 3 and 34%, respectively in the year 2012/13-2021/22 as compared to the year 2003/04-2011/12. Similarly, the production of lentil (42%), chickpea (32%) and grasspea (92%) and also the productivity of lentil (33%), chickpea (25%) and grasspea (49%) has increased in the year 2012/13-2021/22 compared with the year 2003/04-2011/12 (MoALD, 2012 and 2023). The annual growth rate of area, production and productivity in all the winter crops has ranged from 0.4% to 2.1%, and followed the positive trends in all the crops. This is due to the area expansion of the crops and adaptation of improved varieties and production practices developed by GLRP. Moreover, Lentil, chickpea and grasspea are the major legume crops of the Madesh and Lumbini, where more than 73%, 65% and 63% of the area of these crops are recorded, respectively (MoALD, 2012 and 2023). Similarly, Dang, Kailali, Rautahat, Bara and Siraha are the top five lentil growing districts; Banke, Siraha, Kanchanapur, Saptari and Bardiya are the top five chickpea growing

districts, while Nawalparasi west, Sarlahi, Parsa, Arghakhanchi and Morang are the top five grasspea growing and producing districts in the

Nepal. Moreover, Nepal ranks 7th and 5th in terms of area and production of lentil, respectively, in the world (FAOSTAT, 2023).

Table 1. Area, production and yield of winter grain legumes in Nepal

	Lentil	Chickpea	Grasspea
Harvested area (ha)			
2003/04-2011/12	193,221	9,527	7,117
2012/13-2021/22	205,095	9,834	9,514
Percentage change	6	3	34
Annual growth rate (%)	1.2	0.4	1.1
Production (t)			
2003/04-2011/12	172,595	8,082	5,869
2012/13-2021/22	245,048	10,685	11,295
Percentage change	42	32	92
Annual growth rate (%)	2	2	1
Yield (kg/ha)			
2003/04-2011/12	890	848	808
2012/13-2021/22	1,184	1,064	1,200
Percentage change	33	25	49
Annual growth rate (%)	2.1	0.9	2.1

Source: MoALD, 2012 and 2023

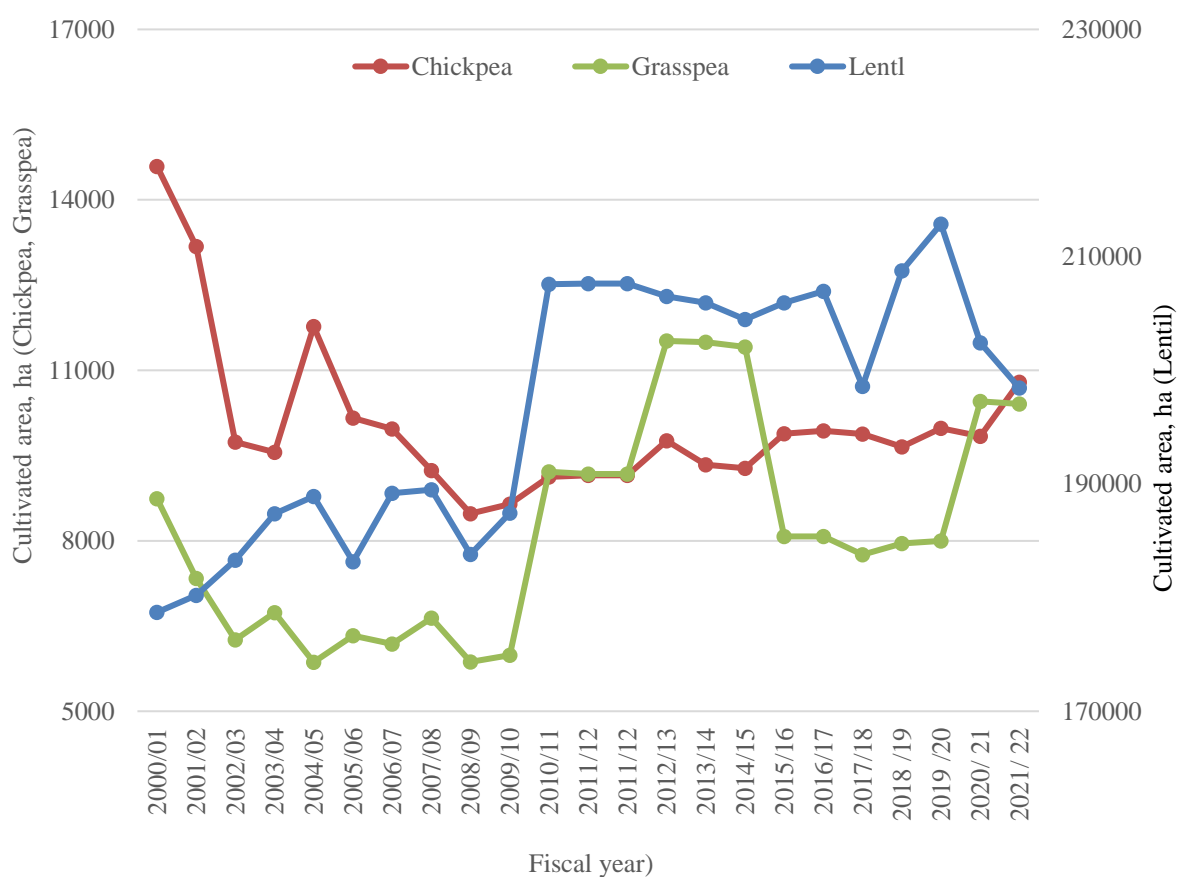


Fig. 1. Trends of area cultivated of major winter legume crops in Nepal
(Source: MoALD, 2012 and 2023)

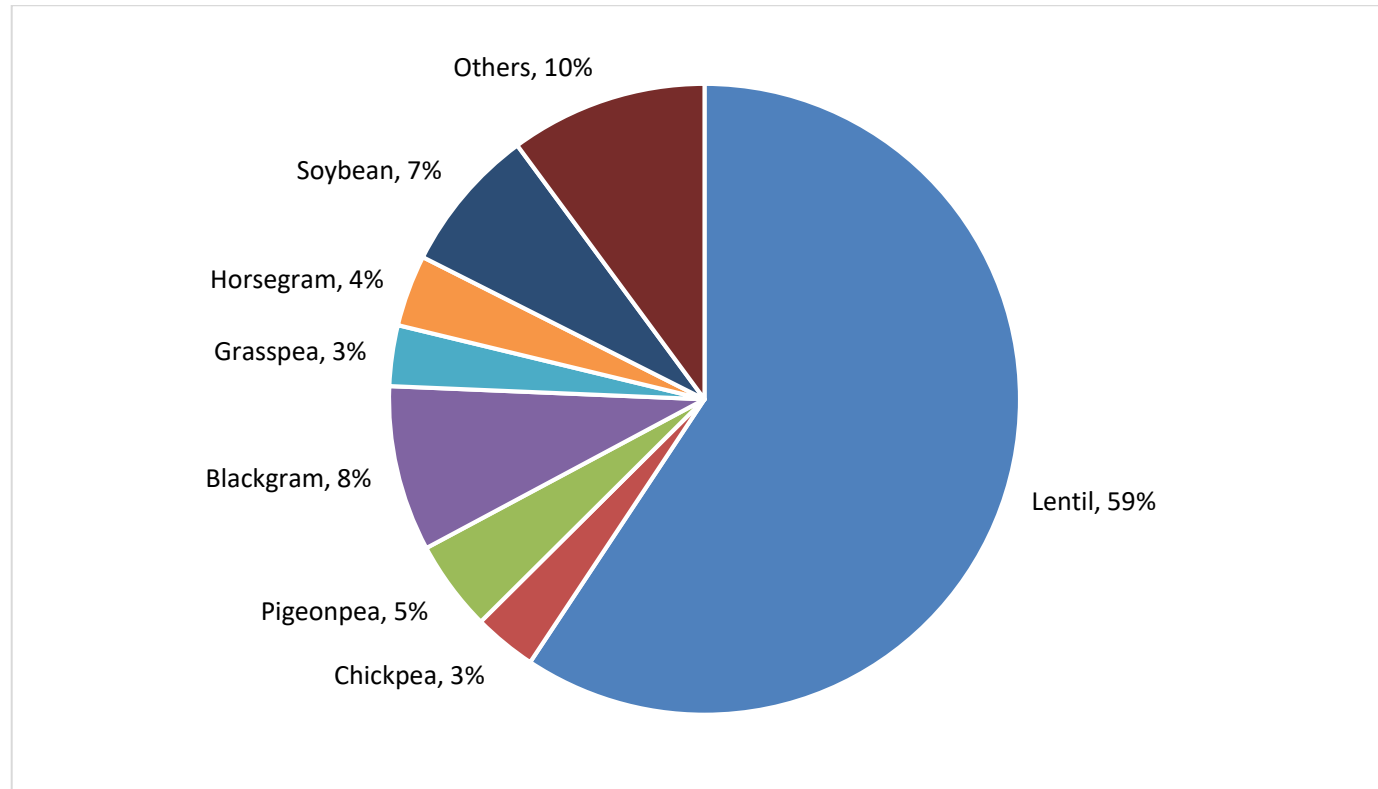


Fig. 2. Area shares (in %) of grain legume crops in Nepal
(Source: MoALD, 2023)

Table 2. Area and its percentage distribution of the winter legumes in provinces of Nepal

SN	Province	Lentil, ha	Chickpea, ha	Grasspea, ha
1	Koshi	14987 (8%)	764 (7%)	1060 (10%)
2	Madhesh	81332 (41%)	3411 (32%)	2401 (23%)
3	Bagamati	3574 (2%)	659 (6%)	489 (5%)
4	Gandaki	5038 (3%)	263 (2%)	121 (1%)
5	Lumbini	64195 (32%)	3549 (33%)	4191 (40%)
6	Karnali	3098 (2%)	1182 (11%)	887 (9%)
7	Sudurpashchim	26230 (13%)	965 (9%)	1259 (12%)

Source: MoALD, 2023

Table 3. Top ten winter legumes growing districts of Nepal

Rank	Lentil (ha)	Chickpea (ha)	Grasspea (ha)
1	Dang (25,323)	Banke (1,368)	Nawalparasi west (2,711)
2	Kailali (20,069)	Siraha (1,255)	Sarlahi (855)
3	Rautahat (17,253)	Kanchanpur (827)	Parsa (631)
4	Bara (14,994)	Saptari (780)	Arghakhanchi (607)
5	Siraha (13,055)	Bardiya (690)	Morang (567)
6	Bardiya (13,013)	Surkhet (555)	Bajhang (505)
7	Saptari (10,020)	Dang (377)	Rautahat (456)
8	Parsa (9,766)	Salyan (360)	Kapilbastu (355)
9	Banke (9,550)	Jhapa (351)	Jhapa (285)
10	Sunsari (6,625)	Kapilbastu (350)	Surkhet (277)

Source: MoALD, 2023

Table 4. Top lentil producing country of the world

Rank	Country	Area in thousand, ha	Production in thousand, t	Productivity, kg/ha
1	Canada	1715	2301	1341
2	India	1412	1269	899
3	Australia	575	1000	1738
4	Turkey	343	445	1299
5	United States of America	244	249	1022
6	Russian Federation	217	258	1189
7	Nepal	198	252	1271
8	Bangladesh	144	191	1320
9	Kazakhstan	143	146	1019
10	Iran (Islamic Republic of)	132	77	580
11	Ethiopia	93	135	1456
12	Syrian Arab Republic	81	27	327
13	China	65	167	2570
	Southern Asia	1894	1793	947
	World	5504	6656	1209

Source: FAOSTAT, 2023

3. IMPORT AND EXPORT SITUATIONS OF WINTER GRAIN LEGUMES IN NEPAL

The national imports of grain legumes was found 147759 t with a net import value of 15005 million NRs that contributed 9% to the total import value of agricultural commodities in the country. Similarly, the winter legumes like lentil, chickpea and kidney bean contributed more than 70% and

64% in the total import quantity and value of the legume commodities. Despite the imports, lentil is an important and potential exportable commodity in the country. Moreover, lentil worth of 569 million NRs was exported from the country, where the contribution of total legume commodities to the total national agricultural commodities was found to be more than 4% (DoC, 2023).

Table 5. Import and export situations of winter grain legumes and their share in Nepal

Commodity	Import		Export	
	Quantity, t	Value, Million NRs	Quantity, t	Value, Million NRs
Lentil	52508	5105	3908	569
Chickpea	47011	4050	43	8
Kidney bean	4080	480	3	0.6
Total winter legume	103599	9635	3954	578
Total legume crop	147759	15005	4092	609
Percentage of the winter legumes to the total legume	70.1	64.2	96.6	94.8
Percentage of the total legume commodities of the total agricultural commodities		9.4		4.0

Source: DoC, 2023

4. MULTI-LOCATION TRIAL SITES FOR GENERATING THE TECHNOLOGY OF GLRP

Grain Legumes Research Program, Banke has been collaborating with the different research directorates/centers/commodity programs/ stations of the NARC, i.e., Directorate of Agricultural Research (Koshi Province), Sunsari, Jute Research Program, Sunsari, Agricultural Research Station, Dhankuta, Directorate of Agricultural Research (Madhesh Province), Bara, Oilseed Research Program, Sarlahi, Agricultural Research Station, Dhanusha, Hill Crop Research Program, Dolakha, National Agronomy Research Centre, Lalitpur, National Plant Pathology Science and Research Centre, Lalitpur, National Plant Breeding and Genetic Research Centre, Lalitpur, Directorate of Agricultural Research (Gandaki Province), Kaski, Horticultural Research Station, Kaski, Horticultural Research Station, Dailekh, Agricultural Research Station, Jumla, Directorate of Agricultural Research (Karnali Province), Surkhet, Ginger Research Program, Salyan and Directorate of Agricultural Research (Far Western Province), Doti, for developing the technologies of grain legumes in the country.



Fig. 3. Multi-location testing sites of GLRP
(Source: Pokhrel & Poudel, 2024)

5. RESEARCH ACCOMPLISHMENTS IN WINTER LEGUMES

5.1 Lentil

More than 100 genotypes of lentil are under evaluation in different trials. Fourteen varieties of lentil have been released and recommended for general cultivation in various geographical locations in the country, and the genotypes PL 4, ILL 7979 and HUL 57 are selected as promising lines for release. Similarly, 207 germplasms of lentil are conserved in the gene bank of NARC (Pokhrel and Poudel, 2024).

For lentil cultivation, early maturing varieties are preferred, with a recommended seed rate of 40 kg per hectare and a planting spacing of 25 cm in rows with continuous seeding. Seeds should be treated with Bavistin (Carbendazim) at the rate of 2.5 g per kg before sowing. The ideal seeding

time is the second week of October, within the Nepali month of Asoj, preferably following the harvest of early maturing rice varieties (less than 125 days). Seed priming can be done either by soaking seeds in water for 8 hours or treating them with a 250 ppm solution of sodium molybdate (Na_2MoO_4). In relay cropping systems, lentil seeds can be sown fifteen days before rice harvest when the soil still retains moisture or at a foot-print soil moisture condition. For mixed or intercropping, lentil can be combined with rapeseed at seed rates of 30 (lentil):2 (rapeseed) kg/ha, 20:6 kg/ha, or in a 2:2 row pattern. Additionally, seeds should be inoculated with *Rhizobium leguminosarum* at the rate of 5 g per kg of seed to enhance nitrogen fixation.

Nutrient management involves applying 20:40:20 kg N:P₂O₅:K₂O per hectare, or 4.3 kg DAP, 1.7

kg potash, and 0.5 kg urea per ropani, but in fertile soils, only DAP and potash at the same rates may be sufficient. Weed control is achieved through rice straw mulching, two-hand weeding at 25 and 45 days after sowing (DAS), or by applying Pendimethalin 30% EC at the rate of 3–4 ml per liter of water just after a day of sowing. Light irrigation should be provided just before flowering to support plant growth. For the management of stemphylium blight disease, spraying SAAF (a combination of carbendazim and mancozeb) or chlorothalonil at the rate of 2.5 g per liter of water at weekly intervals is recommended starting from disease onset.

5.2 Chickpea

More than 100 genotypes of chickpea are under evaluation in different trials. Though, seven varieties of chickpea have been released and recommended for general cultivation various geographical locations in the country, among them one variety 'Trishul' has been de-notified due to its production constraints like wilting susceptibility. Likewise, genotypes ICCV 97207, KPG 59 and ICCX 840508-31 have been selected as promising lines among the tested genotypes in different trials of GLRP.

Chickpea should be sown between the 1st to 2nd week of November (3rd to 4th week of Nepali *Kartik* month) using 40 kg/ha seed for small-seeded and 60 kg/ha for bold-seeded types varieties. The recommended spacing is 40 cm between rows and 7 to 10 cm between plants. Seeds must be treated with Bavistin (Carbendazim) at the rate of 2.5 g per kg seed. Before sowing, seeds can also be soaked in water for 8 hours or in a 2% solution of calcium sulphate (CaSO₄) for better germination. Chickpea can be grown in mixed or intercropping systems with linseed (2:1 line ratio) or rapeseed (4:2 line ratio). Seeds should also be treated with *Rhizobium mexcellany* (cowpea strain) at the rate of 5 g per kg of seed to improve crop growth in low fertile land.

Nutrient management involves applying 20:40:20 kg N:P₂O₅:K₂O per hectare, or 4.3 kg DAP, 1.7 kg potash, and 0.5 kg urea per ropani. In fertile soil, just 4.3 kg DAP and 1.7 kg potash per ropani is enough for chickpea production. Similarly, for the management of weeds, applying of rice straw as a mulch or weeding

by hand at 25 and 45 days after sowing or spray Pendimethalin 30% EC at the rate of 4 ml per liter of water after a day of sowing were found effective. A light irrigation should be done before flowering to support plant growth.

Pod borer is the most important pest of chickpea production, the use of pheromone traps (Helilure) for monitoring, and applying of HaNPV or Multineem (2.5–3 ml per liter water) or Spinosad (0.5 ml per liter water) once their appearance found helpful. Intercropping with coriander also helps for the management of it. Yellow sticky traps or spraying a mix of 50% Chlorpyrifos and 5% Cypermethrin at the rate of 2 ml per liter water can also be able to reduce the pest populations. For diseases like fusarium wilt and foot rot, spraying of saff (a combination of carbendazim and mancozeb) or Bavistin (carbendazim) at the rate of 2.5 g per liter water at one-week interval seemed beneficial. For Botrytis gray mold management, Ronilan (vinclozolin) is found effective at the same dose and interval.

5.3 Kidney Bean

The GLRP has released one variety of kidney bean in Nepal and genotypes Arun 2, Chitra and Coll# 21 are identified as the promising varieties from the trials conducted in different locations of Nepal.

The ideal sowing time of kidney bean is the last week of October or immediately after harvesting early maturing rice in rice–kidney bean cropping system. A seed rate of 90 to 100 kg per hectare is recommended and a narrow row spacing has been more effective than wider row spacing, with an optimal planting distance of 40 to 50 cm between rows and 10 cm between plants. The fertilizer is recommended at the rate of 100:60:40 kg N:P₂O₅:K₂O per hectare with 5 tons of farm yard manure. For weed control, mulching with rice straw is found beneficial. The two-hand weeding at 25 and 50 days after sowing (DAS), followed by ridging is recommended for weed management. To manage diseases, seeds should be treated with Captan at 2 g per kg of seed. In case of white mould appearance, three foliar sprays of Copper Oxchloride at the rate of 2 g per liter of water should be applied at seven-day intervals starting from the first appearance of the disease.

Table 6. Recommended and promising varieties and their characteristics of lentil

SN	Variety	Origin	Released year, BS	Recommended domain	Crop duration	Productivity	Special character
Recommended variety							
1	Sindur	Nepal (LO-1110-25)	2036	Terai to hills	145	1.5	Wide adaptation
2	Shishir	India (P 43)	2036	-do-	150	2.0	-do-
3	Simrik	India (T 36)	2036	-do-	143	1.5	Medium bold seeded, wilt tolerance
4	Simal	India (LG 7)	2046	-do-	143	4.1	Small seeded
5	Shikhar	Pakistan (ILL 4404)	2046	-do-	143	3.5	Wilt tolerance
6	Khajura Masuro 1	India (LG198)	2056	Mid to far western terai	128	1.5	-do-
7	Khajura Masuro 2	ICARDA (PL 639)	2056	-do-	134	2.1	Bold seeded, wilt tolerance
8	Shital	ICARDA (ILL 2580)	2061	Terai to hills	134	1.1	Wilt tolerance
9	Maheswor Bharati	ICARDA (ILL 7982)	2064	Kathmandu valley and river basins	111	1.4	Bold seeded, wilt tolerance
10	Sagun	ICARDA (ILL6829)	2064	-do-	98	1.3	-do-
11	Khajura Masuro 3	Nepal (RL 4)	2073	Terai to river basins of hills	145	1.5	Tolerant to stemphylium blight
12	Khajura Masuro 4	ICARDA (ILL 7723)	2075	Mid to far western terai	136	1.1	Tolerant to wilt and stemphylium blight
13	Shraddha Kalo Masuro	Nepal (Black lentil)	2075	Terai to hills	142	1.3	Tolerant to wilt and stemphylium blight, good test
14	Rasuwa Kalo Masuro	Nepal (Black lentil)	2075	Rasuwa (1800-2500 masl of eastern hills)	150	1.3	Brand of Rasuwa, good test
Promising varieties							
1	ILL 7979	Special character: short duration, tolerance to high soil moisture, tolerance to stemphylium blight, medium in yield					
2	PL 4	Special character: short duration, bold seeded, tolerance to stemphylium blight, zinc-rich					
3	HUL 57	Special character: short duration, bold seeded, tolerance to stemphylium blight, selenium-rich					

Source: Pokhrel and Poudel, 2024

Table 7. Recommended and promising varieties and their characteristics of chickpea

SN	Variety	Origin	Released year, BS	Recommended domain	Crop duration	Productivity	Special character
Recommended variety							
1	Dhanush	Nepal	2036	Terai and inner terai	144	1.8	Drought tolerance
2	Radha	India (JG 74)	2044	-do-	142	1.6	-do-
3	Sita	ICRISAT (ICC 4)	2044	-do-	140	1.5	-do-
4	Kalika	ICRISAT (CL 82108)	2047	Mid to far western terai and inner terai	153	1.4	Suitable for mid-western terai
5	Kosheli	ICRISAT (ICC 32)	2047	-do-	154	1.6	Suitable for mid to far-western terai
6	Tara	Nepal (ICCX 840508 -36)	2064	Terai to hills	135	1.4	-do-
7	Avrodhi	India (Avrodhi)	2064	-do-	135	1.3	Suitable for mid-western terai
Promising varieties							
1	ICCV 97207			Special character: bold-sized seed, tolerance to wilting and blight			
2	KPG 59			Special character: medium-size seed, tolerance to wilting and blight			
3	ICCX 840508-31			Special character: early duration, bold seeded, tolerance to blight			

Table 8. Recommended and promising varieties and their characteristics of kidney bean

SN	Variety	Origin	Released year, BS	Recommended domain	Crop duration	Productivity	Special character
Recommended variety							
1	PDR 14	India (PDR 14)	2075	Terai to mid hills	144	1.8	Tolerance to anthracnose and white mould
Promising varieties							
1	Arun 2	Special character: early maturing and attractive seed coat color					
2	Chitra	Special character: early maturing and attractive seed coat color					
3	Coll# 21	Special character: medium in yield and attractive seed coat color					

5.4 Grasspea

Nepalese grasspea land races generally contained high (0.6 to 0.8% of the acid ODAP) neurotoxin— β -*N*-oxalyl-L- α , β -diaminopropionic acid (β -ODAP), therefore, it is most important to develop the low ADOP (0.01 to 0.02% ODAP) containing grasspea varieties that are safe for human and animal health. The low ODAP containing grasspea genotypes, Bidhan-1 Ratan and GP-97 found better genotypes in terms of their yield at GLRP.

6. RESEARCH STRATEGY OF GLRP FOR GENERATING TECHNOLOGIES FOR WINTER LEGUMES

The Grain Legumes Research Program (GLRP) has set several future strategies for the research and development of winter grain legumes in Nepal. These strategies include the collection of local germplasm and segregating materials from International Agricultural Research Centers (IARCs) for evaluation, selection, and recommendation of improved varieties. Emphasis is placed on identifying sources of resistance to major diseases and pests, as well as understanding the key constraints of winter legume production in the farmers' fields. Proven technologies developed through research will be verified under real farming conditions. The breeding program will be strengthened with a focus on molecular breeding and the development of early maturing, heat-tolerant, and waterlogging-tolerant varieties. Additionally, efforts will be made to develop nutrition-rich, bio-fortified, and low-toxin grasspea varieties. Research will also focus on crop simulation modeling to predict production outcomes and ensure sustainable water use. Integrated pest and disease management, postharvest handling, value addition, cropping systems, and residue management will be prioritized. Technologies for nutrient loading, weed management, climate resilience, and the standardization of foliar urea spray for balanced nutrition will be developed. Mechanization in legume farming will be promoted. The GLRP aims to become a national data center and technology transformer center/center for excellence of grain legumes. Major focuses will be on the collection, conservation, and use of local landraces, along with the production and supply of breeder and foundation seeds. Strong collaboration with national and international research institutions will be fostered, and efforts will be made to

enhance market linkages for grain legumes across the country.

7. COLLABORATION

The GLRP works with partners to enhance the production and productivity of grain legumes in Nepal. It has been working with different international institutions for germplasm exchange such as: International Center for Agricultural Research in Dry Areas (ICARDA) for lentil, chickpea and grasspea; International Crops Research Institute for the Semi-Arid TroFs (ICRISAT, India) for pigeonpea and desi type chickpea; AVRDC (World vegetable Center, Taiwan) for mungbean and vegetable type soybean; International Institute of Tropical Agriculture (IITA, Nigeria) for cowpea and soybean, and national institutions such as: RARs, ARs and disciplinary centers of NARC for technologies evaluation, verification and germplasm conservation; Seed Quality Control Centre (SQCC) for variety release; agricultural offices for technologies transfer. Similarly, the GLRP works with different NGOs, farmers' groups, farmers' cooperatives, and seed companies for the dissemination of technologies at the farm level.

8. CONCLUSION

The GLRP in collaboration with various national and international agricultural research organizations has led to the release and recommendation of fourteen varieties of lentil, seven varieties of chickpea and one variety of kidney bean with their appropriate cultivation/production technologies ultimately resulting into a substantial increase in lentil, chickpea and grasspea production (42, 32 and 92 percent, respectively) and productivity (33, 25, 49 percent, respectively) in the country.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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