Lentil Production in Nepal

A Success Story of Fruitful Partnership
between
Nepal Agricultural Research Council (NARC), Nepal

and

Center for Legumes in Mediterranean Agriculture (CLIMA), Australia
International Center for Agricultural Research in the Dry Areas (ICARDA), Syria

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Foreword

The Asia-Pacific Association of Agricultural Research Institutions (APAARI), is one of the viable Fora to facilitate in research collaboration among various national and international institutions. It acts as a catalyst to promote and strengthen cooperation in agricultural research for development among member countries in the Asia-Pacific. It also ensures agricultural priority setting in the region in the context of global trade and climate change and according to changing food habits and farmer's need. APAARI also plays a key role in linking CGIAR, FAO and other international bodies with the Asia-Pacific National Agricultural Research Systems (NARS) through research partnerships and knowledge sharing. APAARI, through its series "Success Stories", communicates major achievements in agricultural R&D, especially their impact on farmer's fields and on national economy.

In the recent past, the "Cereals and Legumes Asia Network" (CLAN), based at ICRISAT, India has been expanded on APAARI's recommendation to include lentil as one of its mandate crops. The International Center for Agricultural Research in the Dry Areas (ICARDA), Syria has the world mandate for lentil improvement. ICARDA as a co-facilitator of CLAN, is now very much linked with the national programs in South Asia. Countries such as Bangladesh, India, Nepal and Pakistan together produce about 50% of world's lentil. Hence, lentil as a pulse crop contributes significantly towards nutritional security in the region.

Lentil is the most important pulse crop of Nepal due to its role as human food, animal feed and for the sustainability of rice-based cropping systems. It alone occupies about 60% of area and production among a dozen of pulse crops grown in Nepal. It is important for domestic consumption as well as for export. Its daily consumption as *dahl* with rice provides nutritional security to the majority of Nepali population since it is a rich source of protein, macro and micronutrients, carbohydrate, fiber, etc.

Its straw is highly valuable animal feed and the crop is quite important for crop diversification and sustainable agriculture.

The National Grain Legume Research Program (NGLRP), under the Nepal Agricultural Research Council (NARC), based at Rampur, Chitwan, in the *Terai* region has the mandate for lentil research. Since the beginning of pulses research in Nepal, this Center has worked closely with ICARDA. Under this collaboration, the Nepalese national program receives germplasm from ICARDA and needed support for human resources development. NGLRP has also established strong collaboration with the Center for Legumes in Mediterranean Agriculture (CLIMA), located at the University of Western Australia, Perth under an Australian Center for International Agricultural Research (ACIAR) funded project. Accordingly, the program has made considerable progress both in technology development and dissemination. The farmers of Nepal have benefited considerably from improved varieties, production packages and new cropping systems. The scientists of Nepal Agricultural Research Council, ICARDA and CLIMA, the technology transfer support staff representing Government and Non-Government Organizations and the research leaders are to be complimented for their significant role in benefiting resource-poor farmers.

This success story, "Lentil Production in Nepal" is an interesting document, which APAARI is pleased to publish for the benefit of other NARS in the region. I am sure that this publication will be of considerable interest to all those engaged in lentil research and development in South Asia and elsewhere. My sincere thanks to the authors for compiling this useful information for the benefit of lentil growers and consumers.

R.S. Paroda
Executive Secretary

I. Introduction

Lentil is the leading pulse crop of Nepal. It is grown throughout the country in rice or maize-based cropping systems. Fifty-eight percent of the area and 59% of production of total pulses in the country is contributed by lentil alone (Table 1). Other pulses in terms of area and production are blackgram, pigeonpea, soybean, chickpea, horsegram, grasspea are in the decreasing order of importance. Pulses in general and lentil in particular play a crucial role in supplying the cheapest protein and other micronutrients to the poor and middle class people of Nepal. It plays an important role in enriching the fertility status of soil by means of symbiotic nitrogen fixation, carbon sequestration and enhanced organic matter.

Table 1: Area and production of pulses in Nepal, 2005/06

Crops	Area (ha)	Production (t)	Yield (kg/ha)
Lentil	183,000	158,000	862
Chickpea	10,000	8,000	827
Pigeonpea	21,000	19,000	922
Blackgram	33,000	25,000	775
Grasspea	6,000	5,000	756
Horsegram	8,000	6,000	728
Soybean	23,000	20,000	890
Others	29,000	25,000	866
Total	**313,000**	**267,000**	**853**

(Source: Statistical Information in Nepalese Agriculture – 2005/06, Ministry of Agriculture and Cooperatives, Agri-business Promotion and Statistical Division, Singhdurbar, Kathmandu)

Ninety-five percent of lentil area and production is contributed by the *Terai* (the plain or flat land) region (Figure 2). However, there is a huge potential of growing lentils in the hills and high hills, where temperatures are cooler and productivity of lentil per unit area is higher than in the *Terai* region. Lentil is grown in 73 out of 75 districts of

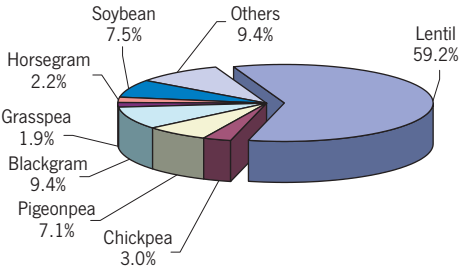


Figure 1: Share (%) of various pulse production in Nepal

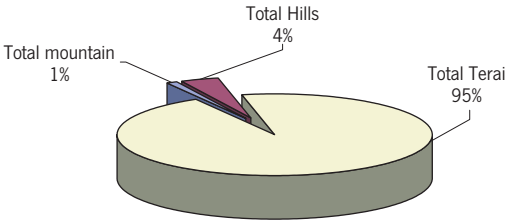


Figure 2: Distribution of pulses in mega-zones in Nepal

Nepal (Figure 3). The important lentil growing districts are: Kailali, Dang, Banke, Bardia, Nawalparasi, Sarlahi, Rautahat, Bara, Parsa, Sraha, Sunsari and Saptari. Lentil is not grown in Manang and Mustang the two trans-Himalayan districts in the western region.

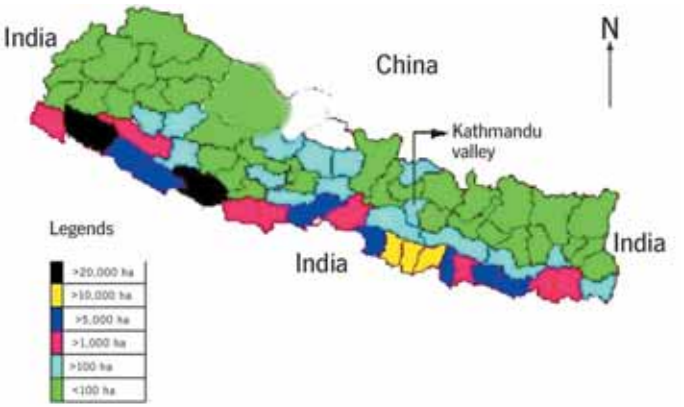
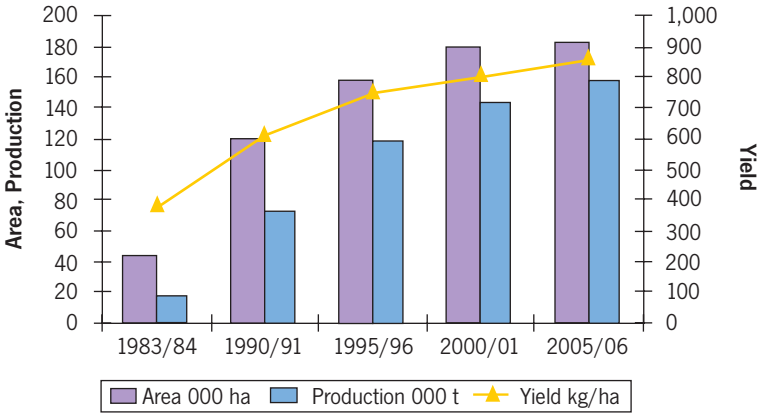


Figure 3: Map showing concentration of lentil cultivation zones in Nepal

Trends in area, production and productivity

Lentil has registered a significant increase in area, production and productivity in recent years (Figure 4). These parameters have increased by several folds between 1993 and 2006. This is due to the increasing popularity of lentil in different cropping systems, the adoption of improved varieties and production technologies, remunerative export market price, additional technical support from different projects working for its promotion and due to a ban on the cultivation and marketing of grasspea since 1991/92 in Nepal (Francis et al., 1997). Increase in production was due to both increase in area and productivity.



(Source: Statistical information in Nepalese Agriculture – 2005/06, Ministry of Agriculture and Cooperatives, Agri-business Promotion and Statistical Division, Singhdurbar, Kathmandu)

Figure 4: Trends of area, production and productivity of lentil in Nepal

II. Cropping Patterns

Lentil is grown either in rice or maize-based cropping systems in Nepal. In the rice-based cropping pattern, it is usually grown as a relay crop or sequential crop with approximately half of the area is under relay sown with rice. It is also grown as an inter-crop and mixed crop with wheat, mustard, linseed, pea, grasspea and chickpea. Mixed cropping lentils with early maturing mustard are widespread in the inner *Terai* and mid-hill regions. Now a-days relay cropping of lentil is gaining popularity throughout the *Terai* regions of Nepal. Farmers have adopted innovative ways of growing lentils; relay-sowing lentil into autumn sown maize is a new emerging pattern being practiced by farmers in the Chitwan area. Mixed or inter-cropping lentils with autumn-planted sugarcane are gaining popularity in sugarcane belts.

Major cropping systems involving lentils

Lowland

Rice-Lentil
Rice-Lentil + Chickpea/Grasspea
Rice-Lentil + Linseed
Rice-Lentil + Mustard
Rice-Lentil-Spring maize
Rice-Pigeonpea on bunds-Lentil
Rice-Lentil-Summer maize (emerging)

Figure 5a: Lentil in a rice-lentil pattern

Upland

Summer maize-Lentil
Summer maize-Lentil + Mustard
Summer maize-Lentil + Mustard + Linseed
Autumn maize-Lentil (emerging)
Sugarcane (autumn planted) + Lentil

Figure 5b: Lentil in a maize-lentil pattern in mid-hills

Why farmers grow lentil?

Farmers in Nepal have realized that lentil is a better option as a winter crop than either wheat or other winter pulses. Due to high input costs of wheat cultivation and increased biotic constraints particularly pod borer and botrytis gray mold in chickpea production, farmers found that lentil is a crop that demands low inputs and is less risky. Good prices received by farmers, lower cost of production, close proximity to the growing export markets in India and Bangladesh are the great incentives for lentil growers in Nepal (Siddique, 1995). Earlier, grasspea used to occupy a substantial area amongst winter pulses. But the rapid decline in the use of grasspea largely because the Government of Nepal bans its production and sale as the local cultivars possess high amount of neurotoxin causing serious health hazards of the poor consumers.

Food habit: Lentil is traditionally a popular staple pulse in the *Terai.* It is consumed as a decorticated split pulse, or whole grain boiled and cooked. It is a constituent of a traditional recipe called *Guanti* (a mixture of 10-12 pulses mixed together, sprouted and cooked). Lentil *dahl* (a concentrated soup) eaten with rice is a popular dish in rural areas (Figure 6). Consumption of lentils is gradually increasing in the mid hills, as lentil cooks faster than other pulses and there is economy of fuel. Compared to some pulses, the price of lentils is lower as indicated by the national average price of pulses in the last 15 years. The national average price of lentils is Nepalese Rupees (NR) 43 per kg compared to 50 NR per kg of blackgram and 54 NR per kg of pigeonpea (AEC, 2006).

Soil health improvement: Farmers have discovered that rice or maize grown after lentil crop yield better than after wheat or oilseeds, suggesting the beneficial effect of crop rotation involving lentils. A Rapid Rural Appraisal (RRA) study conducted in 11 *Terai* districts of Nepal (Morang, Sunsari, Siraha, Dhanusha, Mohottari, Sarlahi, Rautahat, Rupandehi, Kapulvastu, Banke and Bardia) revealed that in

Figure 6: A rural Nepalese family eating rice and lentil *dahl* as a full meal at the beginning of a day

comparison to wheat or fallow lands, legumes (lentils and chickpea) contributed more to enhance yields of succeeding rice ranging between 10 and 40 percent (Pande and Joshi, 1995).

Export: Lentil is one of the key exportable agricultural commodities of Nepal. In the past, lentils were exported to Bangladesh, Republic of Korea, Malaysia, Pakistan, Sri Lanka and European countries via Singapore. In recent years, Bangladesh, Sri Lanka and Pakistan are the major countries importing Nepalese lentils. Up to 48,000 metric tons of lentils have been exported in some years. In 2005/06, lentils worth Nepalese Rupees (NR) 1,035 million were exported to various countries (MOAC, 2006). Unlike other pulses, production of lentil is increasing and stable, as farmers have access to local market for it. Farmers observed that the price of lentil is more stable as compared to other winter pulses. There is good opportunity to export to Arab countries, through improvement in the quality and quantity of lentils (AEC, 2006).

III. Historical Perspectives

Limited lentil improvement activity was initiated in the early seventies and was confined to the evaluation of local and introduced germplasm from India. These materials were tested over different environments in rice- and maize-based cropping systems and three varieties Sindur, Shishir and Simrik were officially released in 1979.

Recognizing the importance of lentils in the national economy, and with a view to enhance the productivity of lentils, research and development efforts were more focused under a grant project of the International Development Research Center (IDRC), Canada in 1985. The headquarters of National Grain Legume Research Program (NGLRP) was then shifted to Rampur, Chitwan, after the creation of infrastructure facilities with supports through agriculture research and production project (ARPP) funded by the United States Agency for International Development (USAID).

In the late eighties, lentil was exported mainly to the European countries. However, the production and hence supply was unstable due to a number of reasons. With a view to stabilize lentil production and imports from Nepal, European Union (EU) provided funds through Trade Promotion Center (TPC) for the promotion of lentils in the early nineties. Infrastructure facilities for seed production, processing and distribution were provided to Agriculture Input Corporation (AIC), which had the sole responsibility of certified seed increase, procurement and distribution in the country. This hastened the distribution of improved seeds to wider areas in the nineties. On-farm trials and extension technician and farmer trainings organized by NGLRP were supported by EC (European Commission) funds. In the late nineties, Asian Development Bank (ADB) funded Secondary Crops Development Project (SCDP) supported for the research and technology transfer of lentils and was valuable for the wider dissemination of lentil varieties in the country during 1990-1999. In

recent years, ADB-funded Crop Diversification Project (CDP) has supported extension activities of grain legumes including lentils in the mid- and far-western region.

From 1995, grain legume research program received funding supports from ACIAR through Center for Legumes in the Mediterranean Agriculture (CLIMA) project PN 9436: Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia which terminated in July 1999. The project was implemented by NARC in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), Syria and CLIMA, Australia. Based on the positive outcomes of the project, ACIAR funded a new project PN CS1/1999/064 "Lentils and Lathyrus in the cropping systems in Nepal – Improving crop establishment and yield of relay and post rice sown pulses" in the *Terai* and mid-hills from 2001-2005. The project utilized the germplasm of ICARDA and other sources for enhancing and stabilizing higher yields.

The NGLRP under NARC has been working to improve lentils through conventional breeding approaches and established technical collaboration with ICARDA since early eighties. Strategies were adopted to develop high yielding lentil varieties suitable for relay sowing with rice and for sequential sowing after rice or maize, through introduction of germplasm and breeding materials from ICARDA and also later from CLIMA, Australia. Top priority was given for collection and evaluation of local and exotic lentils through farmer-participation. Research on improved production packages, including agronomic, cultural and disease management were also carried out simultaneously.

IV. Major Production Constraints

It has been observed that there are huge gap in lentil productivity between national level, demonstrations in farmer's fields and at experimental stations. The average yield of lentil at the national level is 862 kg/ha, whereas research managed trial yields at the farmers' field is 1.5 t/ha, and the experimental yield is up to 3.0 t/ha (Figure 7). This suggests a wide gap between the research station yields, research managed farmers' field yield and the yield at the national level, due to be a number of biotic, abiotic and socioeconomic constraints faced by lentil growers.

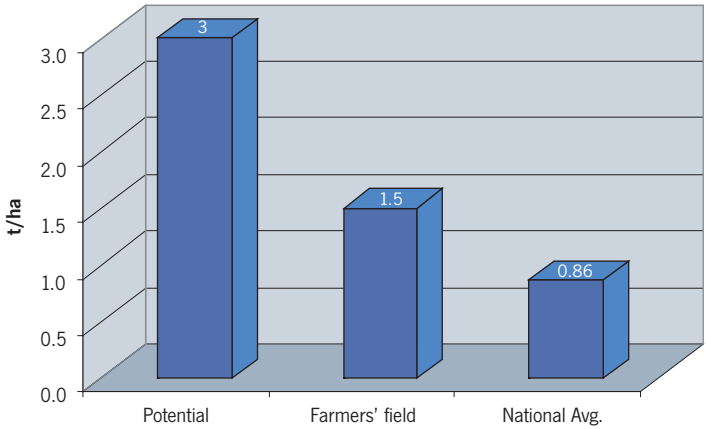


Figure 7: Yield gap in lentil under various production categories

Narrow genetic base, low seed yields and small seed size of local cultivars, and susceptibility to various biotic and abiotic stresses pose serious problems of lentil production in Nepal. Because of smaller seed size, it has become difficult to separate lentil seeds from the vetch *(Vicia sativa)* seeds, decresing market quality.

The key factors related to the low productivity of lentil in Nepal include:

1. Low yield potential of local cultivars
2. Susceptible to diseases: wilt root rot complex, Stemphylium blight. Botrytis gray mold (BGM)
3. Existing cultivars are poorly responsive to inputs
4. Delayed lentil sowing due to late maturing rice varieties reduce lentil yield by shortening the vegetative growth period, exposing lentil to drought and heat stress
5. Yield instability due to intermittent and terminal drought combined with heat stress in spring discourages farmers to grow lentil
6. Lack of farmers' motivation about improved varieties and technologies
7. Inadequate extension services
8. In-efficient quality seed production of improved varieties and distribution systems
9. Non-adoption of improved agronomic practices both in relay and in post-rice lentils.

Among biotic stress factors, wilt, root rots, Stemphylium blight, Botrytis gray mold and bruchids in storage are the major ones (Figure 8). Wilt complex is a serious constraint and farmers experience 25 to 50% yield loss in almost every year. In recent years, the incidence of Stemphylium blight has posed a serious threat in main lentil-growing areas of *Terai* region. Numerous weeds also pose threat to realize potential lentil yield as it is a weak competitor to weeds.

Among abiotic stress factors, early water logging, terminal drought, cultivation of lentil in nutrient-poor marginal and acidic soils with minimal inputs are important. Boron deficiency has created a serious production problem in river basin of Bharatpur region. Under rice-lentil sequential system, sowing of lentil is delayed due to the late harvesting of rice. Lentils sown under this condition in the *Terai* experience forced maturity as a result of increasing temperature and hot

Figure 8: Root and foliar diseases reduces lentil yield to a substantial level. A Nepali pathologist in a farmer's field

Figure 9: A drought affected lentil field in western *Terai*

winds before maturity in the month of March, resulting in poor yields. Under the rice-lentil relay system, lentil plants are exposed to water logged condition in the early stages, resulting in sub optimal plant stands, though this system allows early sowing of lentils, a precondition for higher seed yields. Plant stands and seed yields are dependent on the moisture status of soils at the time of relay sowing. Unstable and variable yield levels are experienced in relay-sown lentils due to poor crop establishment.

In socioeconomic and institutional constraints, non-availability of quality seeds of improved varieties with reasonable price and inadequate extension services are major problems at farm level.

V. Achievements

Germplasm collection and evaluation

The NGLRP has so far collected and evaluated about 265 local and >1,800 exotic germplasm. The first local collection mission was organized in 1987 as a multi-crop expedition with support from IDRC Canada and collections were made from central to the western Nepal. In 1988, collections were made from central to the eastern *Terai* through support from USAID. In 1995, the second expedition was organized jointly by NGLRP, CLIMA and ICARDA. One hundred forty accessions were collected throughout the *Terai* and inner-*Terai regions* (Robertson et al., 1995.)

The sources of exotic germplasm are mainly from ICARDA. Under the Material Transfer Agreement (MTA), ICARDA regularly supplies International Nurseries comprising of drought tolerant nurseries, early maturing nurseries, and Fusarium wilt nursery. Additionally, targeted segregating populations are specially made for Nepal using its elite landraces and parents of diverse origin. The West Asian materials introduced from ICARDA in early eighties were very late to flower and unsuited to the agro-climatic conditions of Nepal. In

contrast South Asian genotypes and crossbreds are early to flower and mature. Therefore crossing with South Asian materials resulted into transgressive segregants phonologically adapted to Nepalese environments.

In general, indigenous germplasm showed very narrow variability with respect to flowering, maturity and number of seeds per pod and other economic traits. Hence, efforts were made to introduce breeding materials from ICARDA from the initiation of lentil improvement program in Nepal (Figure 10).

Figure 10: Evaluation of lentil germplasm at Rampur, Chitwan

Genetic Enhancement

Development of suitable varieties with stable and higher yields, resistant/tolerant to wilt and Stemphylium blight, and suitable to inter-cropping and relay cropping conditions are the key objectives of lentil improvement in Nepal. NGLRP has been receiving lentil materials from ICARDA for selection of genotypes suited to various

agro-ecological conditions of Nepal. Some of the lines selected from the nurseries have already been recommended as varieties and some are in the process of release.

Collaborative research with CARDA and CLIMA has resulted in the identification of a number of genotypes for both as relay and under normal sown conditions. There is ample scope for increasing the production and productivity of lentil through generation and dissemination of suitable technology for relay and sequential systems for various agro-ecological domains of the country. Recently, a modest crossing program has been operational in Nepal, a number of crosses involving locally adapted varieties and introduced promising lines are made annually. Crosses of local varieties with Precoz (ILL 4605) have been successful and progenies selected from these crosses is at the final stage of evaluation. The lines RL 3, RL 4, RL 9 and RL 12 as outcomes of the local breeding program are being evaluated in preliminary yield trials.

Figure 11: Promising lines are being selected by Nepalese scientists from ICARDA Nurseries

Additionally, selection of varieties with increased seed size (25>g/1,000 seed), is a new consideration given to the varietal development in response to the growing demand for medium/bold seeded lentils in the local and export market. Research conducted under various systems has resulted in the identification of a number of varieties (Figure 12) and production technologies of lentil. Eight varieties along with their cultivation practices have so far been recommended to the farmers (Table 2).

Table 2: Lentil varieties released in Nepal

Variety	Name	Source	Yield (t/ha)	Year of rel.	Characteristics	Recommended domain
Sindur	Lo-111-25	Nepal	1.5	1979	Wide adaptation	*Terai*, mid-hills
Simrik	T36	India	1.5	1979	Tolerant to wilt	*Terai*, mid-hills
Shishir	P43	India	2.0	1979	Wide adaptation	*Terai*, mid-hills
Shikhar	ILL4404	ICARDA	3.5	1989	High yield, mod. wilt resistant	*Terai, inner Terai* and mid-hills
Simal	LG7	India	4.1	1989	High yield, bold, mod. wilt resistant	*Terai, inner Terai,* mid-hills
Khajura 1	LG198	India	1.5	1999	Mod. wilt resistant	Mid-western *Terai*
Khajura 2	ILL 2573	ICARDA	2.1	1999	Mod. wilt resistant	Mid-western *Terai*
Shital	ILL 2580	ICARDA	1.95	2004	Wilt resistant	*Terai*, inner and mid-hills

Separate statistics on adoption and cultivation of improved varieties are not available. However, based on house-hold surveys, interaction with local extension officers and farmer's group, the use of released varieties is about 78% in the mid-western *Terai* and 66% in the country. Of the varieties, Khajura 2 and ILL 7723 are most popular in the mid-western *Terai.*

Promising lines awaiting release

It is interesting to note that researchers have identified seven more lines from ICARDA-supplied genetic stocks for future release (Table 3). Farmers of mid-western *Terai* (Nepalganj area) are very

Figure 12: A woman farmer and her daughter in all field of "Shekhar" variety in Ratna Nagar village in Chitwan

Table 3: Potential lines selected from ICARDA nurseries at pre-release stage

Genotype	Source	Yield Potential (t/ha)	Recommended domain	Special traits
ILL 4402	ICARDA	1.9	*Terai* and mid-hills	Wide adaptation, moderately resistant to wilt
ILL 7982	ICARDA	3.0	Mid-hills	Resistant to wilt, bold seeds
ILL 6829	ICARDA	2.2	Mid-hills	Resistant to wilt, bold seeds
ILL 7723	ICARDA	2.5	Mid-western *Terai*	Bold seed, moderately resistant to wilt and Stemphylium blight
ILL 7537	ICARDA	2.0	*Terai* and mid-hills	Medium bold seeds, moderately resistant to wilt, Ascochyta blight and Stemphylium blight
ILL 7979	ICARDA	2.4	Mid-hills	Medium bold seeds, moderately resistant to wilt and drought tolerant, erect
ILL 8006	ICARDA	1.8	*Terai*	Early, resistant to Stemphylium blight and wilt

proud with the line ILL 7723, a medium bold seeded line, moderately resistant to wilt and Stemphylium blight, and suitable for both relay and post-rice sown conditions. Farmers have observed that the variety is better than the earlier recommended varieties. Local extension agencies and NGOs have initiated seed increase and dissemination of the variety before its official release in the mid-western *Terai.* Until recently >15 tons of seeds were produced and distributed to farmers in Nepalganj through community-based seed increase program initiated by NARC-CLIMA-ICARDA collaborative project.

Additionally, ILL 7982, ILL 6829 (Figure 13) and ILL 7979 are promising lines in the mid-hills with high yields, higher seed weight than the earlier recommended varieties, and are resistant to wilt and Stemphylium blight diseases. Seed increase of these lines is underway. Information from farmers' field trials and farmers' reactions are being gathered to support their release in mid-hill regions, where the people are mainly dependant on pulse protein.

Figure 13: Pre-release lines ILL 7982 (left) and ILL 6829 (right) are under seed increase for mid-hills

The line, ILL 8006, an erect and early maturing lentil line. It is released in Bangladesh as *Barimasur-4* variety. Farmers have liked the variety due to its earliness and suitability in rice-lentil-spring maize multiple cropping pattern in Chitwan valley. It can be harvested 15 days earlier than the existing varieties and local cultivars with moderate yield levels. Farmers opined that cultivation of this variety will not hamper the existing pattern and will fit in a new rice-lentil-maize pattern.

Some of the pre-release lines are already been cultivated by farmers. For example, ILL 7723 has been adopted by farmers in Nepalganj areas. The coverage of the line was reported to be 48% at Dang, Banke and Bardia districts. Farmers reported that >20 tons of seed was sown in 2005/06 crop season, and ILL 7723 is replacing the local cultivars, which are susceptible to diseases.

Improved management technologies

Under the NARC-ICARDA-CLIMA joint collaborative research activities considerable research progress is made in the development of improved production packages and fine-tuning of some old techniques. Some of these are described below.

a. Sowing time: Time of sowing is an important factor in realizing higher yield in lentil. In Nepal, lentil is grown on conserved soil moisture after monsoon rain. When grown in rice relay system, it can be sown in the last week of October. In the post-rice system, it is grown from November until the mid-December. Research results show that, sowing lentils after mid-November results in drastic yield reduction. Depending on the cropping systems and elevation, lentils may be successfully sown from late-September to mid-November. Early sowing is desirable in the western *Terai,* where temperatures rise in early March. In the maize-based systems in mid-hills, lentils should be sown just after maize harvest to take full benefit of the residual soil moisture (Neupane and Bharati, 1993). In mid-hills where frost is a problem, it should not be planted before late-October to avoid flower damage by frosts.

b. Seed rate: A seeding rate of 40 kg/ha is optimum for realizing good plant stand and yield of lentil in post-rice cultivation. However, for optimum plant stand and crop canopy geometry, actual seed rates would vary among varieties with variable seed size and various cropping systems. Seed rate up to 45 kg/ha for bold seeded varieties >2.5 g/100 seeds) and for relay sowing is recommended.

c. Relay sowing: Relay sowing lentil in rice field is an age-old practice in South Asia (Figure 14). Approximately half the area in Nepal is under lentil is in relay cropping in rice field. Yield of relay-sown lentils is known to vary with the moisture status of soils at sowing, duration of rice varieties and soil types. Under rainfed lowland conditions, the optimum time for relay sowing is 15-20 days before the harvest of rice for getting higher seed yields (NGLRP, 2000). A seed rate of 40-50 kg/ha depending upon the moisture condition of soil is optimum for relay sowing.

Figure 14: Relay lentil in rice field in west Chitwan

d. Seed priming

Lentil in Nepal is grown on conserved residual moisture of monsoon rain in post-rice planting. Sub-optimal plant stand of lentil due to poor emergence as a result of inadequate moisture status of soils at sowing is often a major problem in area where rice is harvested late resulting delay in lentil planting. Research results have indicated that yield improvement is possible with seed priming for post-rice lentil production. Days to emergence, plant establishment, early vigor and yield were improved by priming seeds for 12 hours in plain water followed by 2 hours air drying the seeds before sowing. Approximately 40% increase in seed yield due to priming alone was recorded from experiments conducted at Nepalganj (Table 4).

Table 4: Effects of seed priming on days to emergence, plant stands and seed yield of lentil variety Khajura 2, Nepalganj

Priming hours	Days to emergence	Plant stand /m²	Seed yield g/m²	% Yield increase over control
0 (Control)	9.4	129	106	
4	8.9	132	107	0.9
8	8.2	144	142	33.0
12	**8.1**	**144**	**148**	**39.6**
16	7.0	137	135	27.3
24	7.0	141	153	44.3
LSD (0.05)	0.42	7.4	19	–
CV %	12.5	23	29	

e. Mixed and inter-cropping

Farmers cultivate lentil as mixed- or inter-crop with winter cereals, oil seeds and with other legumes, as insurance to failure of any one individual crop. In experiments conducted over the years, rapeseed mustard *(Brassica compestris variety Toria)*, which matures in 2.5-3 months before mid-podding of lentil plants, was the found the most compatible mixed and inter-crop with lentil. Thirty kg of lentil and 2 kg of mustard per ha was the best seeding ratio for realizing higher yield

Figure 15: Effect of seed priming in plant stand. A farmer's field in the village Geetanagar in Chitwan (on the left – seed primed for 12 hrs. and on the right – without priming).

and profit from mixed cropping under rain fed condition (Darai, et al., 2000). Inter-cropping lentil with autumn planted sugarcane was found to the most profitable combination with a high land equivalent ratio. These recommendations are being followed by farmers and producing higher yield and realizing more income.

f. Weed management

Lentil is a weak competitor to weed and suffers under both relay and sequential systems. Weeds should be kept under control at least in the initial growth stages. Studies conducted at Rampur has shown that pre-emergence application of isoproturan @1 kg ai/ha in 400 liters of water was effective against broad-leaved weeds in post-rice lentils and resulted in yield increase of 26 percent over the weedy check and 20 percent over the manually weeded plots. In relay-sown lentils, weeds are major constraints to higher production. In this situation, 1-2 hand weeding is beneficial. First weeding to be done 20-25 days and 2nd weeding at 45-50 days after sowing are effective, and recommended.

Figure 16: Experiments on inter-cropping with mustard and linseeds at Rampur

g. Disease management

One of the major constraints to production of lentil in Nepal is disease, which cause substantial yield losses due to attack by a range of pathogens. Of the 10 fungal diseases recorded in Nepal, wilt (*Fusarium* oxysporum f. sp. *lentis*), collar rot (*Sclerotium rolfsii*), black root rot (*Fusarium solani*), Stemphylium blight (*Stemphylium botryosum*) (Figure 13), rust (Uromyces fabae) and botrytis gray mold (Botrytis cineria) are important and cause considerable yield loss in different areas (Joshi, 2003). However wilt root rot complex and Stemphylium blight are the major diseases and are the major threats of lentil cultivation in Nepal.

Resistance sources against these diseases have been identified mainly from ICARDA. In Fusarium wilt nine resistant lines have been identified.

Figure 17: Stemphylium blight affected farmer's field in western Chitwan

Root rot complex is widely observed in the *Terai*. ILL 6256 were found highly resistant. The lines, ILL 8006, ILL 4605, ILL 6002 and ILL 8008 are resistant to Stemphylium blight disease.

The following integrated disease management options are recommended to the farmers:

1. **Seed treatment:** Seed treatment with Captan, Thiram or Bavistin @2 g/kg seeds is very effective to protect the crop at early stages from the soil and seed borne pathogens.
2. **Clean cultivation:** Removal of un-decomposed plant debris is essential. All the stubbles should be removed at the time of land preparation; otherwise they serve as a potential source of soil fungi, which damage the germinating seedlings.
3. **Avoid water stagnation:** Excess soil moisture will predispose the plants to soil-borne diseases.

4. **Crop rotation:** To reduce the inoculum build up in the field, lentil should be rotated with winter cereals and oilseed crops. If wilt is observed in the field, lentil should not be grown for at least 2 years in the wilt affected field.
5. **Fungicide spray:** For the control of Stemphylium blight and botrytis gray mold diseases, fungicides, Bavistin @1 g/liter water or Di-thane M 45 @2.5 g/liter of water should be sprayed when the disease appears at flowering stage.

h. Rhizobium inoculation

Farmers in the lentil-growing areas are convinced of the beneficial effect of seed dressing with Rhizobium inoculation which is recommended to farmers. The Soil Science Division provides Rhizobia culture in nominal price with instruction procedures to treat the seeds. Rhizobium strains tolerant to acidic soils have been identified and being evaluated under field condition.

VI. Institutional Linkages

Institutional linkages with International Agricultural Research Centers (IARCs), regional institutions, and R&D organizations within the country has been one of the features of lentil improvement in Nepal.

Collaboration between NARC and ICARDA started in early eighties. With a recent MOU signed between these organizations, the linkage has been further strengthened. Nepal has been receiving germplasm and improved genetic stocks in the form of various international nurseries, segregating materials and special nurseries over the years. As landraces possess a very narrow genetic variability, ICARDA is the key source in enriching the genetic diversity of lentils in Nepal. However, very recently, CLIMA-selected lentil genetic stocks are being made available to study their adaptation in Nepalese

conditions. To date, more than 1,800 breeding lines have been received from ICARDA, some have been selected for immediate release. The Plant Genetic Resources Unit under NARC conserves these materials under long-term and medium-term storage conditions. The working collections are handled by the NGLRP.

ICARDA is helping the national program in Nepal in making special crosses using locally adapted varieties/landraces and high yielding ICARDA lines of West Asian origin. With the help of ICARDA, NGLRP has been able to secure Stemphylium blight tolerant genetic materials in recent years. The decentralized breeding approach of ICARDA has helped to select disease resistant single plants from segregating populations adapted to various agro-ecological conditions of Nepal.

Institutions involved in Research and Development

Research on lentils is coordinated by NGLRP, administered from Rampur, Chitwan. Lentil materials are evaluated in a wide range of environments in *Terai*, inner-*Terai*, mid- and high-hills at NARC stations situated across the country (Figure 18.)

Figure 18: Lentil research and testing sites in Nepal

Technology verification and validation of proven technologies are carried out in 50 outreach sites in the command area of NARC research stations. On-farm evaluation of lentil technologies is carried out in collaboration with local extension office. Besides, district agriculture development offices, several NGOs/CBOs are involved the R&D of legumes including lentil. They are: Plan Nepal, CARE Nepal, Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Local Initiatives for Biodiversity Research and Development (LI-BIRD), Farmers Seed Producer groups, Agro-vets etc.

VII. Human Resources Development

Capacity building of NARC scientists/technical staff through formal and informal training, visits and participation in workshops/meetings is one of the major achievements of the NARC-ICARDA-ACIAR collaborative activities with longer-term benefits to the Nepalese national program.

Researchers have participated in short-term trainings and study visits organized by ICARDA to learn hybridization techniques, field layout of complete and incomplete statistical designs, electronic data capturing, management and analysis, crop management, etc. The program making use of crossing techniques learned at ICARDA. NARC plant pathologists were trained at ICARDA in screening techniques and for the management of Fusarium wilt disease and this has helped in the evaluation of materials in wilt sick-plots in Nepal. The wilt nursery developed and supplied by ICARDA are thus valuable assets in selection of wilt-resistant lines to progress for further agronomic evaluation. An account of all training/visits/participation in workshops is given in Table 5.

Additionally, in-country trainings and workshops have been important in enhancing the technical skills and broadening the

Table 5: Participation in overseas trainings/visits/ workshops by NARC researchers during 1986-2007

Year	Training	Workshop	Visit	Host-country	Sponsor
1986	–	1 week (1)	–	Thailand	ACIAR
1990	3 weeks (1)		1 week (1)	Thailand	FAO-CGPRT
1991	–	1 week (3)	–	India	ICARDA
1991	2 weeks (1)	–	–	Syria	ICARDA
1992		1 week (1)		Egypt	IDRC-ICARDA
1997		2 weeks (2)	–	Australia	ACIAR
1997	–	2 weeks (2)	–	France	CLIMA
1998	6 weeks (1)	–	–	Australia	CLIMA
1998	4 weeks (1)	–	–	Syria	ICARDA
1999	3 weeks (1)	–	–	Syria	ICARDA
2001	8 weeks (1)	–	–	Australia	ACIAR
2002	4 weeks (1)	–	–	Syria	ICARDA
2002	2 weeks (1)	–	–	Australia	CLIMA
2003	–	–	2 weeks (1)	Australia	ACIAR
2004		1 week (2)		Australia	ACIAR
2004	–	–	2 weeks (1)	Australia	ACIAR
2004	–	1 week (2)	–	Syria	ICARDA
2002-05	PhD (1)	–	–	Australia	ACIAR
2005		1 week (1)		India	ICARDA
2006	4 weeks (1)	–	–	Syria	ICARDA
2007	6 weeks (1)	–	–	Syria	ICARDA
2007	1 week (20)	–	–	Nepal	ICARDA-CLIMA

In paranthesis-number of persons.

knowledge-base and capabilities of national staff. Such courses were organized time to time by ICARDA, ICRISAT and CLIMA at various places of Nepal. A statistical course organized by ICARDA-CLIMA during 2003, 2004 and 2007 were valuable for upgrading the skills of Nepalese scientists in statistical analysis of field experiments and multi-environmental trilas. Lentil workshops organized at Rampur in 1987 and at Nepalganj in 1999 were fruitful in prioritizing lentil research areas in Nepal. The South Asian lentil improvement

conference held at Kathmandu, Nepal in 2003 with active supports from ICARDA, APAARI, CLAN and CLIMA was very fruitful in exposing the Nepalese scientists and administrators in lentil research and development.

Cereals and Legumes Asia Network (CLAN) has also played significant contribution in capacity building of NARC legume researchers through on-farm participatory research, participation in workshops/trainings, monitoring tours, specialized course in breeding, plant protection, disease screening techniques etc.

Figure 19: Mr Rajendra Derai from Nepal (middle) among others for a hands-on training on lentil improvement research at ICARDA

VIII. Factors Underlying Success

For the past two and a half decades, the Nepalese pulses improvement program has put emphasis on research and development to disseminate improved technologies to farmers. In past 10 years, NARC-ICARDA-CLIMA project put tremendous emphasis in the following areas:

- Varietal assessment through farmer participatory varietal selection (PVS)
- Large scale demonstration as farmer acceptance tests (FAT)
- Foundation seed production of improved varieties
- Distribution of seeds, fertilizers and other inputs to the farmers
- Farmers' training and study tours
- Organizing field days and farmer's rallies at crop maturity
- Training of research/extension/NGO field staff
- Community-based seed production programs established
- Establishing linkage with other R&D actors for technology validation and dissemination
- Establishing linkage with other projects for the uptake/ scaling up of technology

Breeder and foundation seed production was mainly the responsibility of NARC stations and farmers' association. NGLRP Rampur, RARS Nepalganj, Agronomy Division Khumaltar, ARS Surkhet, RARS Parwanipur, NORP Sarlahi, and NRRP Hardinath were the main NARC centers involved in production of foundation seed of recommended and pre-released varieties.

Large scale farmers' field demonstrations served as the resource center of lentil technologies. Improved technologies were demonstrated and compared with farmer's practices. During the last few years, over 700 field demonstrations were conducted in intensive lentil-growing areas in Nepal.

Varietal assessment through Participatory Varietal Selection (PVS)

A participatory approach was followed in technology generation and dissemination involving all partners in program planning, execution and monitoring. Farmer participatory research is strongly encouraged by NARC and ICARDA and specific allowance was made in the project budget for these initiatives. Farmers are given an opportunity to assess new varieties and at the same time contribute greatly to the rate of seed increase and subsequent uptake of successful lines. PVS trials consisting of 8-10 genotypes were tested in 100 m^2 plots per genotype in farmer's field in their own management in rice-based system in the *Terai* and in smaller plots (20 m^2) in maize-based patterns in the mid-hills. Inputs and supervision was provided by the research team. Farmers and other partners were allowed to select the varieties or technologies best suited to them.

Monitoring and Field Days organized at the sites provided an opportunity for the farmers, extension workers and researchers to interact and select the varieties/technologies. The enthusiasm of the farmer groups for this type of approach is apparent in villages, such as Betahani in the Nepalganj area, which has become a model farmer participatory group. The group approach also provides an excellent vehicle for dissemination of research results on relay cropping and seed priming. Local NGOs and extension offices used to pick up the suitable variety/technology and promote it through the up-scaling program.

Seed production and distribution: In Nepal, non-availability of quality seeds of improved varieties is a bottleneck for faster dissemination and adoption of improved varieties. Seed production and distribution through organized sector is almost non-existent. Farmer to farmer exchange of seeds is the major channel of seed diffusion. Hence in this project, participant farmers were encouraged to multiply seeds and sale it to other farmers, NGOs and others (Figure 20). Recently,

some private seeds growers associations e.g., Seed Producers Group Pithua, Malla Biz Concern,Tandi Chitwan and others have emerged as successful seed entrepreneurs.

To encourage private sector seed entrepreneurs, source seed was made available through the project and entrepreneurs were involved in training and monitoring of field demonstrations, as incentives.

Table 6: Certified seed production of improved lentil varieties by Nepal Seed Company

Year	Certified seed (tons)	Year	Certified seed (tons)
1992/93	27	1999/2000	10
1993/94	42	2000/01	15
1994/95	66	2001/02	27
1995/96	36	2002/03	17
1996/97	61	2003/04	13
1997/98	27	2004/05	12
1998/99	55	**Total**	**408**

(Source: Statistical information in Nepalese Agriculture 2004/05 Ministry of Agriculture)

Figure 20: Seed increase of ILL 7723 in a farmers' field at Betahani village

Establishing linkage with other R&D actors

Formal and informal linkages were established with other R&D actors involved in developmental activities. They were invited in trainings, monitoring tours and were supplied with promising materials for testing. This provided an opportunity for them to evaluate the materials, select and promote the best technology in the uptake pathways. For the project, it was a golden opportunity to have tested the materials beyond the project sites. This made the environment suitable for the wider dissemination of the varieties. For example a NGO working in Nepalganj area organized seed increase of 10 ha of ILL 7723 in 2003/04 and 20 ha in 2004/05. More than 15 tons of ILL 7723 produced were sold to different districts for sowing in 2004/05 season. Some other NGOs promoting lentil technologies are LI-BIRD, FORWARD, PLAN Nepal and CARE Nepal.

Figure 21: Farmers, researchers, extensionists, and NGO staff participating in a lentil field day in Nepalganj

Regular refresher training to extension staff organized at regional training centers under DOA and attended by NARC scientists as subject matter specialist was instrumental in the delivery of lentil information to the extension field staff.

IX. Adoption and Impact

The targeted technology transfer activities of lentil are underway for the past decade in major lentil-growing areas in Nepal. Department of Agricultural Extension is responsible for the transfer of technology of all the crops including lentil. Research stations under NARC located in diverse agro-ecological conditions of the country are responsible for on-farm evaluation and validation of technologies. The outreach sites in the command area of research stations act as an interfaces between research, extension and farmers. Farmer preferred varieties and technologies are selected and recommended based on the participatory evaluation by concerned stakeholders. The recommended technologies are scaled-up through distribution of minikits, demonstration, training, and community seed increase coordinated by the district agriculture extension agencies in collaboration with local NGOs. Source seed increase of recommended varieties is done in NARC stations and stations under the department of agricultural extension. Apart from public extension services, farmer-to-farmer diffusion of agriculture technologies is recognized as a priority extension strategy for agriculture development.

Though formal surveys for assessment of impacts have yet to be made, information gathered to-date through formal/informal ways, official records, farm visits, district reports and farmers interaction, indicate that lentil varieties and production technologies have made significant contribution to improve farm income and livelihoods of farmers through the following areas.

Figure 22: A farmer, M.P. Varma in his lentil field grown in zero-tillage as relay cropping

a. Increase in area and production of lentils
b. Increased dietary intake of lentils
c. Diversification in cropping systems and development of new patterns
d. Increased involvement of R&D organizations in lentil extension
e. Growth of seed producers associations and Pvt. Dealers
f. Increased agro-processing units and exporters

As a result of the dissemination of improved varieties and production technologies, annual yield increments at the national level have been recorded keeping 1990/91 as the base year. In some years the total production has declined due to unfavourable weather conditions as in 1994/95 and 1997/98. Cumulative additional production increases of 84,693 metric tons have occurred over the base production of 1990/91 season (Table 7). The value of additional production

Figure 23: Lentil variety 'Shekhar' in a farmer's filed in Khoirani village

corresponds to NR 2,964 million assuming the selling price of NR 35,000 per ton at harvest. The total amount is equivalent to US$ 42.3 million at current 1 US$ = NR 70. Thus, lentil research and development activities have significantly contributed to the livelihoods improvement of small farmers through additional incomes and the consumers to access to cheap protein besides providing sustainable cropping systems and to benefits to the agro-industries, traders, exporters and the national economy of Nepal.

A household survey conducted in 2006 in the mid and far western *Terai* districts indicated that adoption of lentil varieties has led to significant changes in area production, productivity, household consumption, and sale of lentils for seed and consumption purposes. Farmers from these region reported that income from the sale of lentil was used for meeting their diverse needs because the price of this crop is satisfactory as compared to other winter crops. According to respondents, the income from extra lentil production was used for

Table 7: Annual production of lentil and cumulative increases over 1990/91 base line figures

Year	Lentil production (tons)	Change over previous year (tons)	Cumulative increase over 90/91 (tons)
1990/91	73,220	0	0
1991/92	72,960	-260	-260
1992/93	10,500	32,040	31,780
1993/94	109,162	4,162	35,942
1994/95	99,771	-9,391	26,551
1995/96	117,720	17,949	44,500
1996/97	123,820	6,100	50,600
1997/98	113,520	-10,300	40,300
1998/99	132,290	18,770	59,070
1999/2000	137,343	5,053	64,123
2000/01	143,084	5,741	69,864
2001/02	148,384	5,300	75,164
2002/03	149,900	1,516	76,680
2003/04	158,671	8,711	85,391
2004/05	160,716	2,045	87,436
2005/06	157,963	-2,753	84,693

cultivation of next crop, land improvement, purchase medicine, children's education, maintenance of houses and building brick houses, purchase of agricultural implements and social activities. Thus, increase in production of lentil has significantly contributed to enhance the income and livelihoods of the farmers in Nepal and strengthened the national economy, and these have been possible due to fruitful partnership within national institutions and between national and international organizations.

Figure 24: Improved lentil varieties are being cultivated in mid-hills of Bhaktapur, where there was no lentil earlier

X. Scope of Future Expansion

A vast area (>290,000 ha) remains fallow after rice harvest in winter in the *Terai* and inner-*Terai* regions. With the fine-tuning of existing technology and recommended varieties coupled with aggressive extension/dissemination of technologies, there is ample scope for the horizontal expansion of area and increase in production of lentil in Nepal.

As the local landraces have very small seed size (<18 g/1,000 seeds), medium to bold seeded lentils from exotic sources are liked by the consumers and thus, improvement in seed size is a researchable issue. We have identified promising lines: ILL 4402, ILL 7723, ILL 7537, ILL 7982, ILL 7164, ILL 6829 and ILL 7979, which meet these requirements and are getting popularity among farmers. These lines need to be released soon and their dissemination will bring further expansion and increase in production.

In the mid- and high-hills (1,500-2,300 m above sea level), local landraces of lentils mostly black-seeded are traditionally grown. The delivery of improved varieties through local extension service agencies/ NGOs has added varietal diversity in selected pockets. Longer growing season in the hills offer suitable environment also for medium duration and bold-seeded lentils, which are not suitable in the *Terai.*

The adoption of lentil lines, ILL 7982 and ILL 6829 by small holders at Nagarkot in Bhaktapur, encouraging results of these lines at Duku Chhap village in Lalitpur and the adoption Khajura 1 and Khajura 2 in Jumla (2,300 m asl), demonstrates that the crop has a good opportunity of being expanded in the hills. There is more scope for crop diversification in the hills through introduction of lentils in their cropping pattern. The expansion of areas has already begun due to the joint efforts of NARC and other development organizations in R&D of lentils.

Lentil as a pulse is gaining popularity among middle class Nepalese due to its lower market price and the less time required for cooking as compared to the other pulses. As a result, the domestic demand is bound to increase. Proximity to Indian and Bangladeshi markets is the plus points for its export opportunities. Ease of cultivation and low production cost compared to other winter crops is an additional advantage persuading farmers to go for lentils.

The Tenth Plan of the Government of Nepal has fixed the overall goal of poverty reduction and food security as visualized by Agricultural Perspective Plan. As lentil is a cash-generating crop, increasing the production and productivity of the crop will augment the national policy of ensuring food and nutritional security, through availing easy access to location specific varieties and technologies.

In future, more focus should be given to farmer participatory research/scaling-up of the station-proven technology so that varieties/ technologies could be efficiently selected for location specific situation.

The involvement of farmers groups, extension service providers and NGOs in on-farm research will catalyze the dissemination of new improved technologies to the target farmers' groups.

XI. Secrets of Success

The following factors played catalytic roles in increasing lentil production in Nepal. Still there is a vast scope for horizontal expansion and productivity as well. Hence, the overall goal was to increase the production of lentils through area expansion in rice-fallows and productivity increase through better varieties and other management options. The present success obtained is attributed to:

- Cultivation of improved lentil varieties with appropriate production technologies.
- Low cost production technologies, e.g., relay cropping with rice and minimum intervention (e.g. mixed cropping), so that marginal farmers can adopt it easily.
- Support provided by ICARDA in terms of lentil genetic materials adapted to Nepalese agro-climatic conditions, technical backstopping, arranging financial support and human resources development.
- Financial assistance provided by ACIAR/CLIMA for farmers' participatory and adaptive research, training and seed increase apart from station research.
- Increased demand of lentils in domestic market and remunerative export market-driven incentives for growing lentils.
- Healthy market flow. Traders and mill owners collect lentil in farm gates and there is no problem of marketing. There are several industries across the country, which are involved in the processing and export of lentils after decortification.

- Effective linkage between farmers, researchers, extension personnel and NGO staff and NARC outreach sites.
- Winter rice fallows are being used for horizontal expansion of lentil areas.
- Increased interest of local NGOs and donors for the extension of lentil technology
- Simultaneous farmer participatory evaluation and seed increase of promising varieties.
- Increase of seed production groups/seed entrepreneurs for the multiplication and distribution of certified seeds.

XII. Epilogue

Lentil is an important crop commodity in Nepal, where most of the rural poor rely on it for their protein and overall nutritional security. Lentil production in Nepal has increased several folds during past decades and the country has attained self-sufficiency that nullified the drainage of foreign exchange for import. Moreover, Nepal witnessed lentil export after meeting its domestic demands. This has only been possible through sustained research and development efforts by the national program in collaboration with regional and international organizations. Cultivation of improved varieties and adoption of appropriate production technologies by Nepalese farmers has led to the achievements of higher production. This could be an example to follow by national programs in the Asia-Pacific region to achieve similar results. The Government of Nepal, international partners and NGOs have played a crucial role through its support to uplift pulse research and development activities. However, since lentil is sensitive to local market forces and is grown as rainfed crop in marginal lands, sustaining the production level high is not an easy task. The market support price needs to be developed, strengthened and continued.

Adoption and large scale practice of some low-cost improved production technologies such as relay cropping (zero-tollage), seed priming and growing lentil in non-traditional areas of mid-hills will further boost lentil production in Nepal. Similarly, support from Government side needs to be continued and strengthened for seed production, demonstration and dissemination of newly identified improved varieties through farmer-participatory approach in full cooperation with extension department and NGOs. APAARI and CLAN will collaborate to accelerate R&D activities of the NARS in the Asia-Pacific region where lentil is grown as an important crop, to provide food and nutritional security.

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