Technology Demonstrations and Value Chain Interventions for Commercial Promotion of Lentil in Rice Fallows in the Terai of Nepal

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Abstract

Lentil is a leading pulse crop of Nepal. It is also a high value crop, having an immense potentiality of export to other countries. Although Nepal Agricultural Research Council (NARC) has recommended ten varieties and improved production technologies of lentil, the adoption at farmer's field has been low due to which the average yield is far below its attainable yield. Poor access to improved seeds, technical knowledge and services among farmers, and lack of appropriate market intervention are major shortcomings to develop this sector commercially. So, to enhance the productivity and production of lentil and to improve linkages among the value chain actors, FORWARD Nepal implemented the project on commercial farming of lentil in 11 terai districts of Nepal in 2011/12 and 2012/13. The project introduced a technology package consisting of improved varieties, rhizobium inoculation, seed priming and basal application of fertilizer diammonium phosphate (DAP) on a cost share basis with farmer groups. Value chain improvement activities including collective marketing were intervened to help growers realize competitive price of the produce.

The project used HH surveys and group discussions with concerned stakeholders for the study. The effectiveness of project interventions were assessed through baseline and endline surveys of the randomly selected sample households from the project

districts. Data were analyzed using descriptive statistics and ANOVA techniques.

The findings reveal the effectiveness of project interventions in increasing the production, productivity and household (HH) income of lentil growers. As a result of technology adoption, average lentil productivity increased by 18%, total HH production by 44%, area under lentil by 25%, HH sale by 29% and HH income by 115% over the baseline figure. It is concluded that in addition to delivery of technology packages to farmers, improvements in value chains and marketing play crucial roles in enhancing farm level profitability and commercial farming of lentil in Nepal.

1. Introduction

Lentil is a leading pulse crop of Nepal with 207,630 hectares under cultivation (MOAD, 2012). The crop is rich in protein and forms one of the important constituents of Nepalese food. In addition to dietary supply of protein needs at the household level, it has enormous potential for enhancing income of lentil growers from the sale of surplus produce. Although the crop is grown in 73 districts of the country (except Manang and Dolpa), more than 80 percent of area and production is concentrated in the terai districts.

Lentil is also the largest exported item among agricultural commodities from Nepal with a share of about 2.3 percent of total national exports and about 3.1 percent of the total world export (ITC, 2010). Nepal is currently listed among the top 10 exporters and was fifth in 2009 and 2010 in terms of quantity and value in US dollar exported. The Nepal Trade Integration Strategy has also prioritized lentil as one of the 19 commodities with export potential (NTIS, 2010).

The national average yield of lentil is around 1.0 t/ha, whereas the researcher managed trial yield at the farmers' field is 1.5 t/ha, and the experimental yield is up to 3 t/ha (Neupane et al., 2008). This wide gap in yield is due to a number of biotic, abiotic, and socioeconomic constraints faced by lentil growers (Shrestha et al., 2011). The majority of farmers grow lentil in a small area both for domestic consumption and for sale to augment the household cash needs. The sale of lentil is based on the collection of small marketable surplus from each household and commercial production is negligible. Due to smaller sizes of land holdings and inadequate knowledge on processing and marketing, farmers are not able to derive potential benefits from lentil farming (NEAT, 2011). The post harvest losses including harvesting, threshing, cleaning, drying, storage, processing and transportation ranged between 15-20% (AEC quoted in Deve et al., 2007). According to Siddique et al. (2012), for hastening technology transfer to resource-poor farmers, proper understanding of the value chain for the commodity is important. The above mentioned facts clearly highlight the need to disseminate available technology along with production, processing and marketing skills to the farming community for expansion of lentil farming in the vast rice-fallow lands extending from eastern to the western terai and inner terai of Nepal (Subbarao et al. 2001, Stevenson *et al*. 2006).

This paper aims to assess the effect of lentil technology demonstrations and value chain interventions in the adoption of technology package, and changes in lentil production, productivity, sale and household income of smallholder farmers. It deals with lentil production, processing and marketing problems, and prospects of production and productivity increase through technology and value chain interventions through participatory approach in the terai of Nepal. Section 1 describes the importance of lentil in Nepal's agriculture, its contribution in cropping system, daily diets and export along with the problems and prospects. Section 3 deals with available technology packages and definition of terminologies. Research methodology is elaborated in section 4, and section 5 describes the project intervention sites encompassing districts, village development committees (VDCs) and farmer groups. The results of technology demonstrations have been presented and discussed in section 6. Section 7 describes the changes in lentil production, productivity and household income of beneficiaries after project intervention. Lentil market interventions and collective marketing approaches and their effectiveness in enhancing household production and profitability have been described in section 8. The conclusions from the study and a set of recommendations for future interventions have been provided in section 9. We hope the implementation of these recommendations will pave the way for commercial farming of lentil resulting in substantial increases in profits of all actors involved in lentil value chain.

2. Objective of the study

This paper aims to assess the effect of lentil technology demonstrations and value chain interventions in the adoption of technology package, and changes in lentil production, productivity, sale and household income of smallholder farmers. It also provides a set of recommendation to development agencies and lentil value chain actors.

3. Definition of terms

Technology package

Within the scope of this study, technology package consisted of improved varieties of lentil (Simal, Khajura Musuro-2, Khajura Musuro 1, Sagun, or Shikhar), seed priming, rhizobium inoculation and basal application of fertilizer diammonium phosphate (DAP) @ 3 kg/katha (333 sq meter).

Informal research and development (IRD)

Small quantity of improved seeds of recommended lentil variety adequate for sowing in one katha area and information materials for cultivation practices, distributed for free to a large number of farmers for wider dissemination of the variety/ technology.

Seed priming: It denotes overnight soaking of seeds in plain water followed by air drying for two hours prior to sowing in the field to allow for faster and uniform germination and emergence of the crop.

Rhizobium inoculation: It refers to seed treatment with suitable species of Rhizobium bacterium to allow for better and efficient nodulation by nitrogen fixing bacteria. *Rhizobium leguminosarum* is the bacterium used in seed inoculation of lentils.

Sera system: Sera system refers to a reduction in lentil price from the maximum fixed value based on presence of percent impurities in the produce. The system is used by millers in fixing price of lentil brought by producers/ traders.

Rice-fallows: These are lands used to grow rice in the rainy the season but left fallow during the following winter due to technological, social and institutional constraints faced by smallholder farmers.

4. Research methodology

The research methods consisted of a combination of HH surveys, group discussion and interaction with concerned stakeholders. For the study purpose, 11 terai districts were selected based on the extent of area coverage by lentil. In each district, three clusters of villages were selected in consultation with district agriculture development offices (DADO). Beneficiaries HHs from the selected clusters were assigned a unique HH code. Baseline survey was conducted among 3,631 (20% of beneficiaries) randomly selected HHs. The sample sizes differed among districts based on the number of HHs selected from the project districts. For the endline survey conducted after the harvest of year two lentil crop in May/June 2013, a total 1,442 (8% of beneficiaries) HHs were randomly selected from 11 districts.

Yield data from technology demonstrations were gathered from 332 HHs in year 1 and 645 HHs in year 2. IRD data were gathered from 2,533 and 1,323 HHs in year 1 and year 2, respectively. For conducting baseline and endline survey, semi- structured questionnaires were developed and pretested before taking data from the field. Data were collected by field technicians under the supervision of monitoring and evaluation officer. Focused group discussions and interaction meetings were organized for data triangulation and confirmation. Data was tabulated and analyzed using ANOVA technique and the means compared through LSDs. Since our purpose was to validate the effect of demonstration package and IRDs in increasing the yield of lentils over the existing practice, yield data from the two crop cycles were compared with the baseline yield.

5. Study area

Selection of districts for project interventions was based on the extent of area coverage by lentil and the potentials for its expansion in future. The districts selected were Saptari, Sirha, Sarlahi, Rautahat, Bara, Parsa, Nawalparasi, Dang, Banke, Bardia and Kailali (Figure 1). Together, these districts represent around 78 percent in area and production of lentil in Nepal (MOAD, 2012) with each district having more than 5,000 ha area coverage by lentil. In each district, three clusters each consisting of 2-3 villages were selected in collaboration with DADO. All project activities were implemented through group approach with the involvement of farmer groups in collaboration with government line agencies like DADO, NARC and VDCs. In doing so, 669 farmer groups were formed involving 17,537 HHs from 71 VDCs and two municipalities in the selected terai districts.

Figure 1. Map of Nepal showing the project locations

6. Results

6.1 Technology demonstrations

Technology packages consisting of improved lentil variety, seed priming, rhizobium inoculation, and basal application of fertilizer diammonium phosphate (DAP) were demonstrated in all project districts in both years. Data on technology demonstrations conducted during the first and second crop cycles have shown significant increases in productivity of lentil. Mean yield of lentil in demonstration plots was significantly higher (($P \leq 0.05$) than the pre-project level (Table 1). Compared to the base figure, yield increases were 55 percent in the first year and 46 percent in the second year. Yield levels were slightly lower in the second year due to occurrence of late winter rains, high relative humidity in the air and subsequent severe incidences of stemphyllium blight (SB) disease. However, two year mean value showed yield increase by 49 percent over the pre project level. The combined effect of technology resulted in yield increases of lentil in all project sites. Technology interventions failed to enhance yield levels at Bara in the second year, due mainly to the effect of SB disease as the area was low lying and it provided favorable environment for disease development.

6.2 Informal research and development (IRD)

Informal research and development (IRDs) kits distributed to a large number of farmers in the first and second crop cycle had tremendous effects on increasing the yield of lentils. Data collected during cycle 1 and cycle 2 showed average increases in yield of lentil by 36 percent over baseline figure. Lentil yields from cycle 2 IRDs at Rautahat and Dang districts were lower than those at the pre-project levels, due to heavy incidence of SB disease in those districts (Table 2). IRDs essentially consisted of improved variety of lentil and rhizobium inoculum for seed treatment. It is obvious that intervention of seeds and rhizobium along with other improved cultivation practices like weeding was effective increasing the yield levels of lentil. Differences in yield level in IRDs were observed between districts, due probably to differences in sowing time, soil fertility status, and cropping systems followed in those districts. In a review on agronomy of food legumes, Siddique et al. (2012) mentioned that any increasing trends in production of legumes including lentils noted are mainly attributable to the availability of improved varieties or economic factors driving production.

Table 1. Yield performance (kg/katha) of lentil in technology demonstrations vs baseline across years and districts

	Banke	Bara	Bardiya	Dang	Kailali	Nawalparasi	Parsa	Rautahat	Saptari	Sarlahi	Siraha	Overall
Baseline	27.23 (326)	31.48 (323)	18.36 (325)	24.52 (322)	23.78 (328)	22.57 (310)	27.69 (317)	30.44 (315)	13.956 (324)	18.66 (346)	15.77 (405)	22.86 (3631)
Demos 2011/12	36.51 (23)	37.64 (23)	33.25 (29)	32.04 (26)	36.12 (27)	40.23 (24)	40.88 (24)	46.99 (21)	33.952 (23)	34.60 (65)	28.82 (47)	35.53 (363)
Demos 2012/13	41.10 (73)	29.23 (56)	33.25 (68)	33.15 (54)	27.46 (56)	43.32 (54)	36.135 (55)	39.11 (55)	23.22 (55)	25.62 (65)	33.29 (54)	33.21 (645)
F value	26.072 ***	3.496 *	84.405 ***	18.558 ***	16.029 ***	113.946 ***	20.978 ***	56.814 ***	105.583 ***	86.503 ***	143.843 ***	328.553 ***
LSD (0.05)	2.095	1.83	1.319	1.514	1.567	1.470	1.750	1.194	1.029	1.128	1.027	0.482
SE±	0.753	0.659	0.470	0.544	0.563	0.528	0.629	0.429	0.370	0.427	0.369	0.178

*** Significant at 0.001, * * Significant at 0.01 and * Significant at 0.05 probability level

Table 2. Yield performance (kg/katha) of lentil in IRD vs baseline across years and districts

	Banke	Bara	Bardiya	Dang	Kailali	Nawalparasi	Parsa	Rautahat	Saptari	Sarlahi	Siraha	Overall
Baseline	27.25 (326)	31.48 (323)	18.36 (325)	24.52 (322)	23.78 (328)	22.57 (310)	27.69 (317)	30.44 (315)	13.96 (324)	18.662 (346)	15.768 (405)	22.86 (3631)
IRDs 2011/12	31.15 (223)	34.65 (195)	29.30 (232)	30.05 (219)	32.06 (247)	36.38 (210)	33.53 (239)	42.78 (237)	32.21 (230)	33.83 (229)	31.55 (272)	33.37 (2533)
IRDs 2012/13	29.18 (129)	31.10 (132)	22.51 (127)	20.84 (123)	25.27 (113)	34.00 (120)	31.09 (113)	28.05 (112)	19.49 (122)	26.40 (100)	24.53 (132)	26.56 (1323)
F value	6.311 **	4.874 **	90.490 ***	38.029 ***	44.226 ***	136.541 ***	18.774 ***	218.916 ***	289.771 ***	147.129 ***	272.483 ***	648.621 ***
LSD (0.05)	1.355	1.358	1.005	1.071	1.141	1.098	1.203	0.833	0.945	1.115	0.849	0.389
SE±	0.488	0.489	0.361	0.385	0.407	0.395	0.433	0.300	0.340	0.401	0.3059	0.140

Source: Field survey 2010/11, 2011/12 & 2012/13.

*** Significant at 0.001, * * Significant at 0.01 and * Significant at 0.05 probability level

Figures in the parentheses indicate the number of observations.

6.3 Technology adoption

Improved varieties: Improved varieties of lentil were being demonstrated and promoted through the project. Results of endline survey showed 92 percent of respondent households having adopted one or more improved varieties (Table 3). Group discussion with farmers revealed that high yields, fewer incidences of diseases and improved seed sizes were the reasons for adoption of those varieties. Earlier studies conducted in Nepal have also shown increased adoption of improved varieties of chickpea (Pande et al., 2005), lentil and pigeonpea (Neupane et al., 2007) due to the effect of on-farm demonstrations.

Rhizobium inoculation: In case of seed treatment with rhizobium, 56 percent of respondents reported adoption of this practice after the project intervention. It was 11 folds increase from the baseline figure. Focused group discussion with farmer groups revealed that although majority of them were in favor of seed treatment, the availability of rhizobium inoculum was the major factor affecting its adoption. At present NARC is the only reliable organization which produces rhizobium in a limited scale for research and demonstration purpose. Few private organizations involved in its productions do not have sales outlets in lentil production pockets. In smallholder subsistence farming community, rhizobium inoculation is the best option for meeting the nitrogen requirements of legume crops. On-farm research results in Nepal have shown 32 percent yield increase in lentil due to rhizobium inoculation over control (Bhattarai et al., 1997). Similar results have been reported by Sattar et al. (1997) in Bangladesh and Khurana et al. (1997) in India.

Seed priming: Seed priming is a no cost technology introduced by the project and its adoption was reported by 67.9 percent respondents after the project implementation, whereas only 16 percent respondents were practicing it before the project was started. Awareness creation among farmers on its benefits and its importance in having better and uniform emergence of crop together with increased tolerance to diseases were the reasons behind its adoption. Germination of lentil sown after the harvest of main season rice is often poor due to suboptimal soil moisture regimes at the time of sowing. In this situation, primed seeds take less time to germinate and crop emergence is uniform due to the imbibition of water by lentil seeds during the priming period. Harris et al. (1999) has reported beneficial effects of seed priming in germination and emergence of cereals and that of lentil by Neupane (2001). In the context of changing climate and increased drought periods in recent years, seed priming provides resilience to the smallholder lentil growers.

Fertilizer application: Fertilizer diammonium phosphate (DAP) application was reported by 69.7 percent of respondents after project completion. On the contrary only 15 percent were practicing it before the project start. Earlier, farmers in all project area had the false notion of lentil yield increase through urea top dressing which actually led to crop overgrowth and increased foliar diseases leading to reduction in crop yields. They are now convinced of the beneficial effects of basal application of DAP on optimum growth of plants, improved root nodulation, fewer incidences of foliar diseases and high crop yields. However, non availability of DAP at the sowing time was a great hindrance faced by smallholder farmers.

Weed management: The proportion of farmers adopting weed management practices was marginally increased due to project intervention. High labor costs involved in manual weeding was the reason for low level of adoption of weeding practice. Interaction with the farming community revealed that they were in favor of cheaper alternatives to manual weeding. In response to the demand of the community, demonstration plots of pre-emergence herbicide application for the management of broadleaved weeds like Bethe (*Chenopodium album*) in post-rice lentil were established in the second year of the project cycle. Data on weed counts per unit area and lentil seed yield has shown significant effect of herbicide Pendimethalin application in suppressing weed growth and minimizing loss in crop yields due to weed infestation. Mean yield of crops grown in herbicide treated plots was 918 kg/ha while that from the control was only 628 kg/ha (Figure 2). Pandey et al. (1998) also mentioned yield reduction in grain legumes by 25 to 40 percent due to competition from weeds.

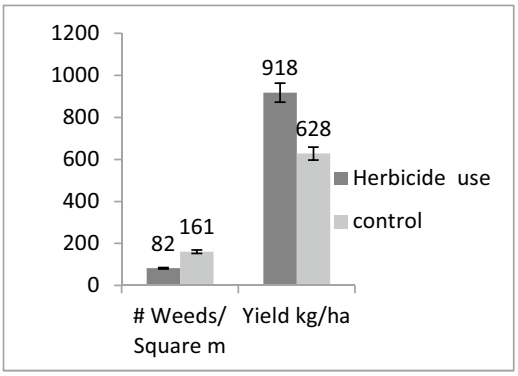

Figure 2. Effects of herbicides on lentil yields

7. Changes in lentil production, productivity and household income after project interventions

With a view to bring tangible impacts on lentil productivity, production and household income of lentil growers, a number of activities including, capacity building of farmers in lentil production, processing and marketing; technology demonstration, IRD distribution, farmers' field days, community based seed production (CBSP) and marketing; value chain tours/excursion visits, workshops; dissemination of technical information through publication in local languages and through local FM radio, etc. were

Table 3. Percent (%) respondents using improved variety, seed treatment, seed priming, DAP application, and cleaning/grading of lentil by project districts

	Banke	Bara	Bardiya	Dang	Kailali	Nawalparasi	Parsa	Rautahat	Saptari	Sarlahi	Siraha	Overall
Improved variety												
Baseline	30.3	4.4	0.8	3.6	1.8	1.7	0.0	3.8	1.9	0.0	2.4	4.4
Endline	100.0	85.7	85.3	100.0	96.8	69.9	89.8	94.2	98.4	90.2	99.3	91.8
Rhizobium inoculation												
Baseline	4.0	0.0	4.0	4.0	4.0	4.0	0.0	0.0	8.0	3.0	2.0	5.0
Endline	43.1	77.1	10.3	61.7	35.0	80.5	56.8	70.3	49.6	70.5	69.1	56.5
Seed priming												
Baseline	2.0	38.7	0.8	0.8	1.5	3.3	68.7	3.1	0.8	19.1	36.7	16.3
Endline	13.9	83.6	54.4	36.8	69.1	72.2	94.9	61.2	77.6	96.4	97.8	67.9
Fertilizer Application												
Baseline	0.8	44.4	0.8	0.4	1.5	42.3	1.5	41.2	26.3	16.1	0	15
Endline	88.9	72.1	45.6	46.6	83.7	91.7	22.9	96.7	97.6	13.4	95.7	69.7
Seed cleaning/Grading												
Baseline	16.7	39.1	53.8	22.7	24.4	70.7	59.6	11.5	1.1	19.1	3.0	28.1
Endline	98.6	100.0	86.0	94.7	95.1	97.0	100.0	92.6	82.4	99.1	97.8	94.9

implemented in project districts during two crop cycles in 2011/12 and 2012/13.

Capacity building: In the beginning, group level trainings on lentil production, processing and marketing were provided to 17,537 selected farmers organized into 669 groups in the project districts. These were field based trainings and handouts outs written in local languages were provided to enable farmers to understand the available lentil technology in proper perspective.

Seed production processing and marketing: To improve access of quality seeds at local level, farmers were organized into 15 community based seed production groups and were capacitated in production, processing and marketing of truthfully leveled (TL) seeds. The linkage of seed producer groups with seed value chain actors was strengthened through organization of seed value chain workshops and seed quality standards workshops during the project period. During project cycle, those CBSP groups were able to produce and market 85 mt TL seeds of lentil.

Seed supports: Seeds of improved varieties of lentil were made available to 17,537 beneficiary households during the two crop cycles. For demonstration and seed production activities, source seeds were supplied on a cost share basis, whereas in IRDs seeds were distributed to farmers for free.

Storage supports: Two hundred and eighteen metal bins of 250 kg capacity each were provided to seed producer groups on cost sharing basis. Similarly, to facilitate collection of lentil seeds and grains, the project supported for the construction of seven collection centers in the project districts.

Supports on seed grading: Farmers were oriented to value addition of lentils through cleaning, grading and packaging interventions. For this, improved sieves of 2.5*2 ft dimension were provided to 426 farmers groups of project districts on cost sharing basis. This enabled the groups to add value to their produce through cleaning and grading both seeds and grains before marketing.

The above mentioned project interventions have helped in bringing impacts in the following areas:

Lentil area per household

Changes in lentil area per household were significant ($P \leq 0.05$). Twenty five percent increases in area per household under lentil were recorded due to project intervention (Table 4). Increase in productivity of lentil in demonstration plots (Table 1) and IRDs (Table 2) has convinced the farmers of the superior performance of improved lentil varieties and technologies, and this has motivated them to devote more land to lentil rather than to wheat or other winter crops which often demand more inputs. Moreover, farmers have experienced improvement in soil fertility and yield increases in the succeeding rice crops after the harvest of lentil. The residual effects of winter legumes to the following rice crop were also found in the survey of eleven terai districts of Nepal (Pande and Joshi, 1995). For smallholder farmers, the savings in costly chemical fertilizer is an additional incentive to go for intensification of the legume crop lentil in their copping system.

Lentil productivity

Significant increase ($P \leq 0.05$) in lentil productivity was observed as a result of project intervention. The adoption of improved technologies has resulted in overall yield enhancement by 18 percent over the pre project level (Table 4). Yield increments were higher in Siraha, Nawalparasi and Sarlahi and Saptari districts. These districts had fewer developmental interventions in the past and therefore pronounced response to the interventions was recorded to these districts. On the other hand, slight reductions in yield levels were recorded in Bara, Dang and Rautahat districts due to late winter rains and subsequent higher incidences of foliar blight disease. Aw-Hassan et al. (2009) has also reported similar yield increases in lentil in Bangladesh due to adoption of improved varieties and technologies.

Household level production, sale and income

Household level production increased significantly ($P \leq 0.05$) over the pre-project level. Overall production increment per household was 44 percent over the base figure (Table 5). Growth in lentil area and productivity has both contributed to this increment.

Lentil growers used to keep 41 percent of lentil for their household use that includes daily consumption as daal and seed. However, after the project intervention, farmers were selling higher proportion of their produce to the market and up to June 2013 they sold 174 kg lentil per HH, and they kept the rest for future sale on the expectation of price rise (Figure 3). Higher prices might have motivated them to sell more volume of lentil in the market. Also, farmers might have opted for consumption of other pulses which are comparatively cheaper than lentil. Moreover, farmers were capacitated in community based seeds production (CBSP); marketing and use of truthfully labeled (TL) seeds instead of recycling their own produce as seed, thus giving them an opportunity to sell more produce in the market. Increase in volume of sale was about 29 percent over pre-project sale volume. Lentil sale volumes from Nawalparasi, Bara and Parsa districts were more than double of the pre-project level.

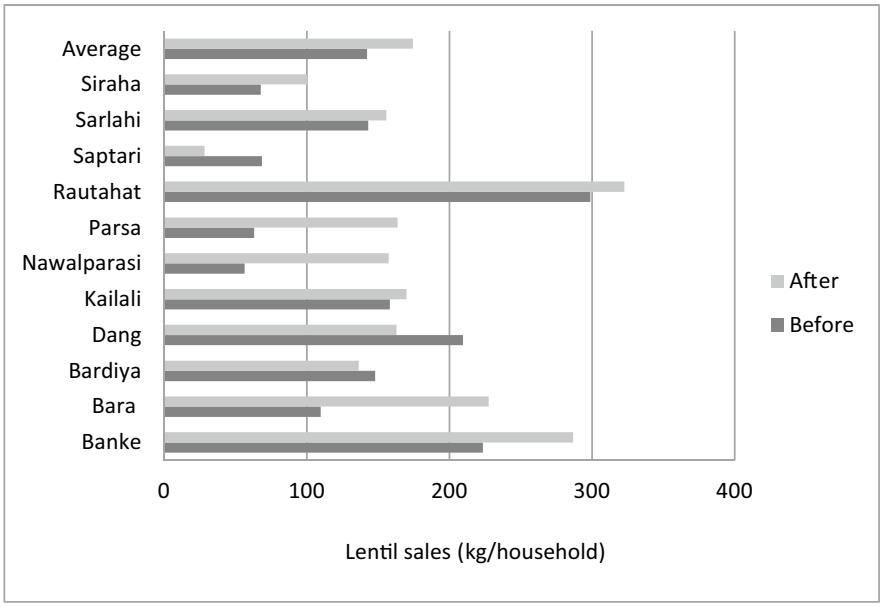

Figure 3. Lentil sale (kg/household) before and after the project intervention

Compared to pre-project status, significant increase ($P \leq 0.05$) in average household income from the sale of lentil was recorded (Figure 4). Average household income was increased by 115 percent over the pre-project value due to increase in the volume of sale as a result of production increases, value addition and rise in market price of lentil (Table 5). The decline in yield of lentil in the second year as a result of increased severity of foliar disease, did not affect much the profitability, due to corresponding increase in the market price thereby less adversely affecting the profitability. Dubey et al. (2011) also reported similar results in a study of pulse production in UP Hills, India.

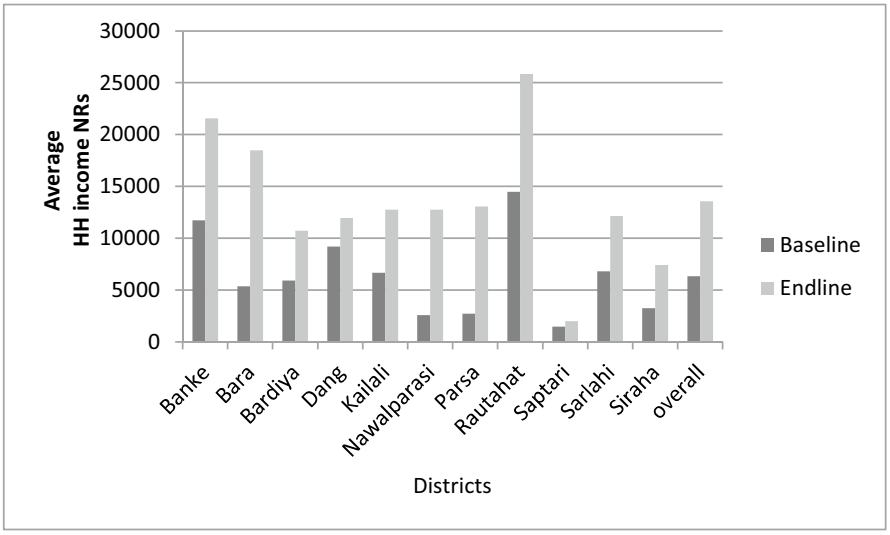

Figure 4. Average household income before and after the project

Table 4. Changes in lentil area and productivity across project districts

Parameters	Banke	Bara	Bardiya	Dang	Kailali	Nawalparasi	Parsa	Rautahat	Saptari	Sarlahi	Siraha	Overall
Lentil area (katha/HH)												
Baseline	11.3	6.8	15.2	13.1	10.9	7.1	5.2	14.2	5.8	11.3	9.0	10.0
Endline	15.9	10.5	12.7	14.5	11.1	9.0	12.1	22.5	5.9	12.1	11.6	12.5
Change	4.6	3.8	-2.6	1.4	0.2	1.9	6.9	8.3	0.1	0.9	2.6	2.5
% Change	41	56	-17	11	2	26	133	59	1	8	29	25
T value	-2.80661	-3.29407	2.276373	-1.00813	-0.18071	-2.12366	-3.62423	-3.84247	-0.13789	-0.80741	-2.74959	-6.01063
P value	0.005***	0.0012***	0.023**	0.314	0.856	0.034**	0.000***	0.000***	0.890	0.420	0.006***	0.000***
Productivity (kg/katha)												
Baseline	27.2	31.5	18.4	24.5	23.8	22.6	27.7	30.4	14.0	18.7	15.8	22.9
Endline	30.7	30.8	22.8	21.2	25.7	34.2	30.8	28.2	19.6	26.6	24.7	26.9
Change	3.5	-0.7	4.5	-3.3	1.9	11.7	3.1	-2.2	5.6	7.9	9.0	4.0
% Change	13	-2	24	-14	8	52	11	-7	40	42	57	18
T value	-1.68911	0.536283	-4.37829	3.220673	-1.49745	-9.78841	-2.83043	2.822855	-5.68164	-8.23557	-12.991	-10.3087
P value	0.092*	0.592	0.000***	0.001***	0.135	0.000***	0.004***	0.005***	0.000***	0.000***	0.000***	0.000***

Note: * and *** indicate significance of 10% and 1%, respectively.

Table 5. Changes in lentil production, sale and income at household level across project districts

Parameters	Banke	Bara	Bardiya	Dang	Kailali	Nawalparasi	Parsa	Rautahat	Saptari	Sarlahi	Siraha	Overall
Lentil production (kg/HH)												
Baseline	338.7	207.3	259.1	315.8	241.1	157.7	138.8	425.4	77.5	227.7	129.3	226.9
Endline	520.7	334.5	231.1	294.3	265.8	290.9	372.6	627.0	113.8	284.8	263.1	327.5
Change	182.0	127.2	-28.0	-21.4	24.7	133.2	233.9	201.6	36.3	57.0	133.8	100.5
% Change	54	61	-11	-7	10	84	169	47	47	25	103	44
T stat	-2.13185	-3.38277	1.513041	0.566719	-0.92597	-4.56424	-3.92748	-3.28024	-3.62274	-2.66159	-7.8645	-7.37454
P value	0.034**	0.000***	0.131	0.571	0.355	0.000***	0.000***	0.001***	0.000***	0.008***	0.000***	0.000***
Lentil sold (kg/HH)												
Baseline	211.06	108.39	147.94	209.57	158.29	56.42	63.15	298.76	31.29	143.09	67.71	134.76
Endline	286.74	227.45	136.48	162.77	169.84	157.43	163.68	322.59	28.28	155.69	100.17	174.45
Change	75.68	119.06	-11.47	-46.80	11.55	101.01	100.52	23.83	-3.01	12.60	32.45	39.69
% Change	36	110	-8	-22	7	179	159	8	-10	9	48	29
T stat	-1.54069	-3.61155	0.775413	1.543254	-0.53128	-4.36614	-2.44841	-0.5906	0.498998	-0.79949	-2.8449	-4.34963
P value	0.124	0.000***	0.438	0.124	0.595	0.000***	0.015**	0.555	0.618	0.424	0.004***	0.000***
HH income (000 NRs)												
Baseline	11.72	5.63	5.92	9.19	6.67	2.58	2.71	14.47	1.47	6.81	3.24	6.32
Endline	21.57	18.47	10.72	11.95	12.75	12.76	13.07	25.84	2.00	12.13	7.40	13.56
Change	9.85	13.11	4.80	2.76	6.08	10.18	10.35	11.37	0.53	5.32	4.17	7.24
% Change	84	244	81	30	91	394	381	79	36	78	129	115
T stat	-2.61816	-5.03468	-5.26199	-1.36068	-4.07291	-5.85631	-3.17204	-3.822	-1.39277	-5.03864	-5.22726	-10.6224
P value	0.009***	0.000***	0.000***	0.175	0.000***	0.000***	0.001***	0.000***	0.165	0.000***	0.000***	0.000***

Note: *** indicates significance at 1% level.

8. Market interventions

Development of collective marketing approach

In view of the small and scattered production of lentil, traders find it less profitable to collect produce from the smallholder producers in villages. To gain an economic scale of marketing, it was important for producers to organize themselves into farmers' organizations such as cooperatives or producers' groups and market their produce collectively through these organizations. To facilitate and promote collective marketing, site specific collective marketing strategies were developed by the organization through workshops and interaction meetings among producers, collectors, wholesalers and millers as appropriate in each project district. In the beginning, a total of 4,072 lentil growers from project area were capacitated on collective marketing and its implementation methods based on the market opportunity existing in their localities. Producer groups were oriented to form collective marketing committee in each production cluster which handled the collective marketing procedure in line with developed strategies. Presences or absence of agricultural cooperatives, CBSPs, local markets, local collectors/wholesalers, collection centers and millers in a particular area were the major determinants of the collective marketing strategy to be adopted in a particular area. The following collective marketing strategies were adopted in the project:

A. Cooperatives taking a lead role: In areas where cooperatives are active and some lentil growers are members of the cooperative, cooperatives will take the lead in collective marketing e.g. Bhuvarbhavani Cooperative at Baijapur, *Krishak Upkar Sahakari Sanstha* (KUSL) Betahani, Banke, and *Suryodaya Krishak Sahakari Sanstha* Bela of Dang district.
B. Producer groups taking lead role: In areas where cooperatives are nonexistent, groups collect lentil and send it to millers directly.
C. Groups farmers sell lentil to wholesalers/big collectors at the village and from wholesalers it goes to millers.
D. In some area farmers them-selves take lentil to millers in adjacent area.

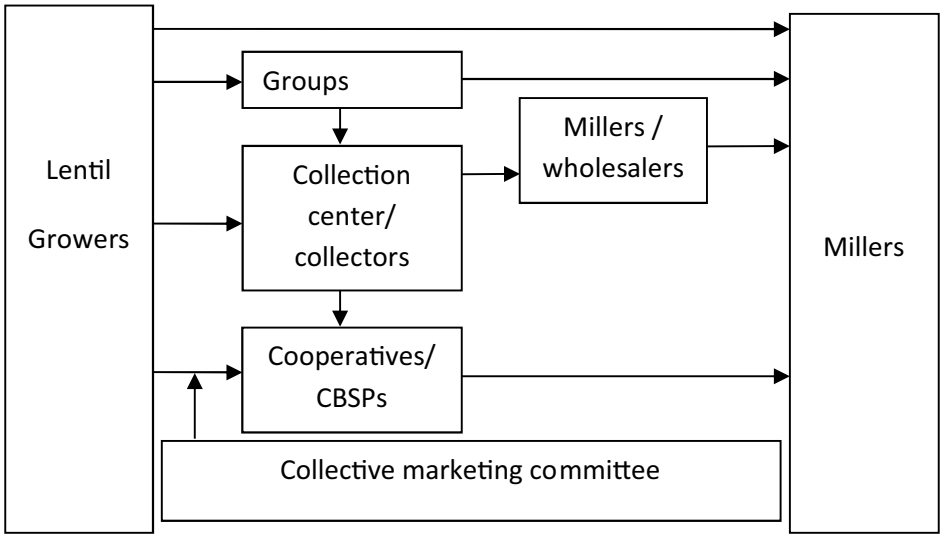

Figure 5. Collective marketing approaches adopted for lentil marketing

The above-mentioned marketing interventions helped strengthen the linkage of 7,343 smallholder producers from 450 groups to other 72 business enterprises (miller/whole- salers/cooperatives/CBSPs) in lentil value chain. Before the project and also during the first year of project intervention, farmers sold most of their lentil to collectors, followed by millers and wholesalers. However, there was a shift in sale destination as a result of technology intervention from the project. Through collective approach, farmers were able to increase their profit margin by NRs 5.83/kg which they would have lost if marketed individually. The supply of bulk quantity of lentil through collective marketing was in favor of millers/ wholesalers who paid extra money for it. By the end of the project, growers sold about 35 percent of produce to millers and wholesalers through collective marketing. Increase in price of lentil in bulk quantity and better quality of produce was a driving force behind collective marketing.

Prices of agricultural crops are built not only on the basis of by local production costs and internal competition but also the international markets largely influence it. Lentil being an exportable commodity, price fluctuates over years in response to the prices in the lentil importing countries. The productivity of lentil is low compared to other cereals, but producers shared that lentil was more profitable and marketable in comparison to cereals due to low cost of production. However, producers did not have precise information on pricing mechanism and they were compelled to agree on the price offered by traders. Capacity building of growers in

value addition of lentil through cleaning and grading, and exposure to the quality standards enabled them to bargain better price for their produce. The orientation to lentil producers to mill owners' quality assessment criterion *Sera system* enabled producers to evaluate their produce on the basis of quality and this has increased their bargaining power. At the project end, producers got a profit margin of NRs 3/kg from value added lentil.

Price changes in the domestic market are often reflected in changes in area coverage by lentil in the succeeding year. Compared to the pre-project level, lentil price received by producers showed an increasing trend in all districts (Figure 6). Area under lentil has simultaneously increased by about 25 percent in the same period (Table 5). Domestic prices are also influenced by the export scenario and export policy of the government. In the beginning of 2009, Nepal government banned the export of lentil on the back of skyrocketing price of pulse in the domestic market during the height of global food crisis in 2008. However, the ban was lifted in 2010. Lentil Prices received by farmers have since then been in increasing trends.

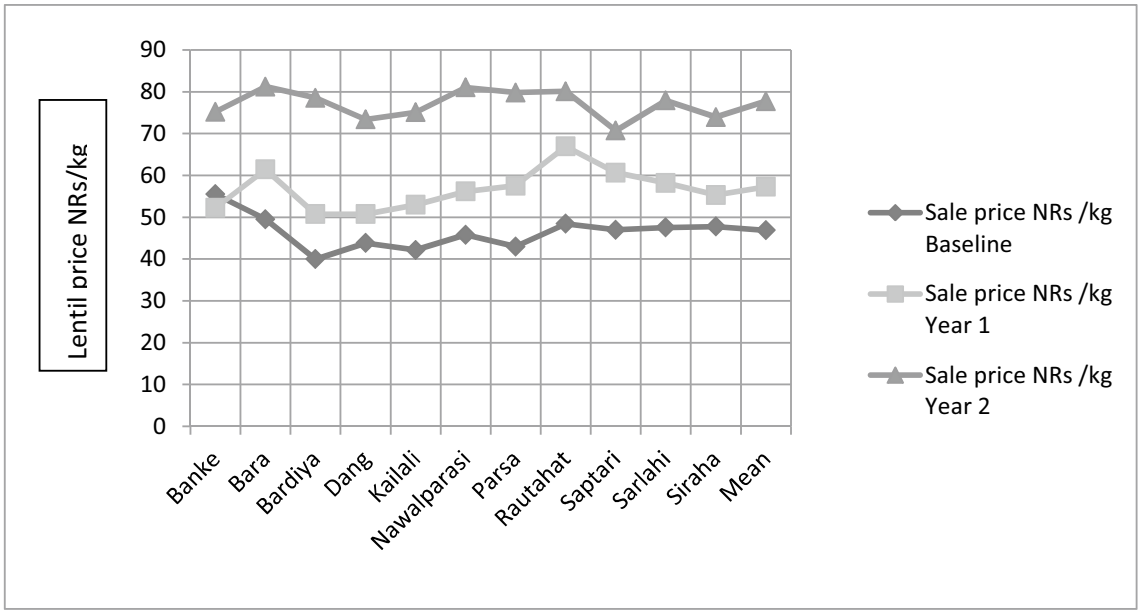

Figure 6. Lentil prices received by producers across districts

9. Conclusion and recommendations

9.1 Conclusion

In this study, the effect of lentil technology demonstrations and value chain interventions on changes in lentil area, productivity, household production, sale and income of beneficiary households were assessed. The technologies and value chains were intervened for two crop cycles among 17,537 HHs of 71 village development committees and 2 municipalities of 11 terai districts of Nepal. The investigations demonstrated that improved technology package consisting of improved lentil varieties, seed priming, seed inoculation with rhizobium and basal application of DAP fertilizer has potentials to increase average crop yields by about 49 percent over the pre-project level.

Capacity building of lentil growers in production, processing, and value addition through grading has increased their bargaining power for pricing their produce. Exposure of growers to value chain actors has strengthened their linkages with the latter and has also enabled them to adopt collective marketing. Farmers were having a profit margin of NRs 3/kg through value addition and NRs 5.83/kg through collective marketing.

The adoption of the above mentioned technologies and marketing strategies has led to increase in overall lentil productivity by 18 percent, area per HH by 25 percent, production per HHs by 44, sale by 29 percent and income by 115 percent over the pre project level.

9.2 Recommendations

Improved technology package of lentil has demonstrated its effectiveness in increasing production of lentils; this should be up scaled in the whole of terai and inner terai districts through mainstream extension agency.

Marketing lentil through collection centers has proved beneficial for the smallholder farmers. However, these centers need

seed money for holding lentil until the market is favorable for them. Therefore, microfinance institutions should be linked with the producer groups and collection centers.

Community based seed productions approach should be further out scaled for improving farmers' access to seeds at local level.

Stemphyllium blight disease has emerged as a big threat to lentil production in recent years. Therefore, competent agency of government or other institutions should initiate and implement integrated management of the disease to counteract the negative effect of the disease on lentil production.

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References

Aw-Hassan, A.A., Regassa, S., Shafiqul Islam, Q.M., and Sarker, A. (2009), The impact of improvement research: The case of Bangladesh and Ethiopia. (Erskine, W., Muehlbauer, F.J., Sarker A., and Sharma, B. eds.) *The lentil: botany production and uses*. CABI, Wallingford, 425-446.

Bhattarai, S., Maskey, S.L., and Karna, R.L. (1997), On-farm experiments on rhizobial inoculants in Nepal: results, problems and possible solutions. *Extending nitrogen fixation research to farmers' field: proceedings of an international workshop*, 20-24 Aug1996, ICRISAT Asia Center, India (OP Rupela, C. Johansen, and DF Herridge, eds.). Patencheru 502324, Andhra Pradesh, India: International Crops Research institute for the Semi Arid Tropics, 235-242.

Deve, F. C., Munanarmi, R., and Biji, B. (2007), Nepal advisory services on export development of priority sector in Nepal: Export performance potentials. Project NEP/A1/OIA. International Trade Centre- NCTAD/WTO.

Dubey, S.K., Sah, U., and Singh, S.K. (2011), Participatory impact assessment of technological interventions disseminated in Bundelkhand region of Uttar Pradesh. *Journal of Food Legumes* (Formerly *Indian Journal of Pulses Research*), 24 (1), 36-40.

ITC, (2011), International Trade Centre. WWW.intracen.org/marketanalysis. Accessed on 12 June, 2011.

Harris, D., Joshi, A., Khan, P.A., Gothkar, P., and Sodhi, P.S. (1999), On-farm seed priming in semi-arid agriculture: development and evaluation in maize, rice and chickpea in India using participatory methods. *Experimental Agriculture*, 35, 15-29.

Khurana, A.L., Namdeo, S.L., Patel, B.J., and Dudeja, S.S. (1997), On-farm experiments on rhizobial inoculants in India: results, problems and possible solutions. *Extending nitrogen fixation research to farmer's field: proceedings of an international workshop*, 20-24 Aug1996, ICRISAT Asia Center, India (OP Rupela, C. Johansen, and DF Herridge, eds.)Patencheru 502324, Andhra Pradesh, India: International Crops Research Institute for the Semi Arid Tropics, 217-226.

Kumar, S., and Bourai, V.A. (2012), Economic analysis of pulses production: their benefits and constraints "(A Case study of sample villages of Assan Valley off Uttarakhand, India) *IOSR Journal of Humanities and Social Science (IOSRJHSS)* ISSN: 2279-0845, 1(4), 41-53. www.iosrjournals.org

MOAD, (2012), Ministry of Agriculture and Development. *Statistical Information of Nepalese Agriculture 2010-11*, Statistical Division, Agribusiness Promotion Center, Hariharbhawan Kathmandu.

NEAT, (2011), Nepal Economic Agriculture, and Trade Activity—Value Chain/ Market Analysis of the Lentil Sub-Sector in Nepal, Contract No. EEM-I-00-07-00008, AID-367-TO-11-00001. *United States Agency for International Development. General Development Office. Kathmandu, Nepal*.

Neupane, R.K. (2001), Effect of seed priming on the growth and yield of lentil Var. Khajura Musuro-2. *Proc of national winter crops workshop (Grain Legumes)*, Parwanipur 12-14, Sept. 2000. National Grain Legume Research Program Rampur, Chitwan, 59-62.

Neupane, R.K., Thakur, N.S., Jha, P., Pokhrel, D.N., Mahato, B.P., and Sah, R.A. (2007), Adoption of wilt management technology in grain legumes: A case study in the mid and far western terai, Nepal. *Proceedings of Eighth National Outreach Research Workshop*, 19-20 June 2007, NARC, Kathmandu, 174-184.

Neupane, R.K., Sarker, A., Shrestha, R., Yadav, N.K., Erskine, W., and Francis, C. (2008), *Lentil production in Nepal: A success story of fruitful partnership between Nepal Agricultural Research Council (NARC), Nepal, and Center for Legume in the Mediterranean Agriculture (CLIMA) Australia and International Center for Agricultural Research in the Dry Areas (ICARDA Syria)*. Asia Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand, 1- 42.

NTIS, (2010), Nepal Trade Integration Strategy-2010: Executive summary and action matrix. Kathmandu: Ministry of Commerce

and Supplies, Government of Nepal.

Pande, S., and Joshi, P. K. (1995), Constraints and prospects of legumes in northern India and the Terai region of Nepal (field observation and group interviews with farmers: Sept-Dec 1995). Patencheru India: International Crops Research Institute for the Semi arid Tropics.

Pande, S., Neupane, R.K., Stevenson, P.C., Grazywacz, D., Bourai, V.A., Rao, J.N., and Kishore, G.K. (2005), Integrated crop management of chickpea in Nepal: past present and future. *Policy strategy for increasing income and food security through improved crop management of chickpea in rice-fallows in Asia. Summary of a NARC-ICRISAT-NRI workshop*, 17-18 Kathmandu, Nepal. ICRISAT, India, 16-24.

Pandey, A. K., Prasad, K., Singh, P., and Singh, R.D. (1998), Comparative yield loss assessment and crop–weed association in major winter crops of mid hills of N-W Himalayas. *Indian J. Weed Sci* 30 (1/2), 54–57.

Sattar, M.A., Khanam, D., Ahmed, S., Haider, M.R., Podder, A.K., and Bhuiyan, M.A.H. (1997), On-farm experiments on rhizobial inoculants in Bangladesh: results, problems and possible solutions. *In extending nitrogen fixation research to farmers field: proceedings of an international workshop*, 20-24 Aug 1996, ICRISAT Asia Center, India (OP Rupela, C. Johansen, and DF Herridge, eds.)Patencheru 502324, Andhra Pradesh, India: International Crops Research Institute for the Semi Arid Tropics, 201-216.

Shrestha, R., Neupane, R.K., and Adhikari, N.P. (2011), Status and future prospects of pulses in Nepal. *Current status and future prospects of pulse production in SAARC countries*, (Nasrin Akter and Abdul Kalam Azad eds.). SAARC Agriculture Centre (SAC), 109-138.

Siddique, K.H.M., Johansen, C., Turner, N.C., Jeoffroy, M.H., Hashem, A., Sakar, D., Gan Y., and Alghamdi, S.S. (2012), Innovations in agronomy for food legumes. A review. *Agron. Sustain. Dev*, 32 (1), 45-64. DOI 10.1007/s13593-011-0021-5.

Stevenson, P.C., Grazywacz, D., Pande, S., and Neupane, R.K. (2006), Promoting the adoption of improved ICM technologies in chickpea by poor farmers in Nepal. (Sweetmore A., Kimmins, F., and P. Silverside eds.), *Perspectives in Pests II. Achievements of research under UK Department for International Development*, Crop Protection Program,2000-2005, Natural Resources International, Ltd UK, 152-154.

Subbarao, G. V., Kumar Rao, G.V.D.K., Kumar, J., Jhonson, C., Dev, U.K., Ahmed, I., Krishna Rao, M.V., Venkatratnam, L., Hebbar, K.R., Sai, M.V.S.R., and Harris, D. (2001), *Spatial distribution and quantification of rice-fallows in South Asia-potential for legumes*. ISBN 92-9066-436-3. International Crops Research Institute for the Semi-Arid Tropics, 316.