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Lentil (*Lens culinaris*) demonstrations for enhanced productivity at farmers' fields in India

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ABSTRACT

The Department of Agriculture Cooperation and Farmers Welfare (DAC&FW) sponsored project on lentil entitled "Enhancing Lentil Production for Food, Nutritional Security and Improved Rural Livelihoods" was implemented by International Center for Agricultural Research in the Dry Areas (ICARDA), South Asia & China Regional Program (SACRP) collaboration with National Agricultural institutes SAUs and NGOs. This study was implemented in nine districts of four zones i.e. Eastern Himalayan Region (Nagaon, Assam) (Zone-I), Lower Gangetic Plains Region (Malda and Murshidabad, West Bengal) (Zone-III), Middle Gangetic Plains Region (Patna, Nalanda and Muzaffarpur, in (Bihar) and Ballia and Chandauli (Uttar Pradesh) (Zone-IV) and Upper Gangetic Plains Region (Fatehpur, Uttar Pradesh) (Zone-V). Demonstrations on lentil were conducted in these zones during 2010-11, 2011-12 and 2012-13. The increase in per cent of yield was ranging between 27.65 to 64.99 per cent. The technology gap and extension gap were ranging between 4.63 to 15.53 q/ha and 1.72 to 5.35 q/ha, respectively. The technology index was ranging in between 25.72 per cent to 64.80 per cent. By adopting improved production technologies, productivity can be increased which will further uplift in the socio-economic level of the farming communities.

Key words: Lentil, NFSM, Productivity, Technology Gap, Technology Index

Pulses are essential ingredients in the vegetarian diet which much of the Indian population, relies on, thus providing a perfect mix of protein component of high nutritional value when supplemented with cereals (Ali and Gupta, 2012). Also important for existing farm production systems as it adds nitrogen to soil and provides food and nutritional security to large number of vegetarians and weaker sections of the society; who cannot afford other sources of protein (Kokate *et al. 2013*). In India, 23.10 Million hectare area cultivated with pulses with 7.44 q/ha productivity and 17.19 MT production in 2015-16 (Directorate of Economics and Statistics, DAC & FW, 2015). The average productivity of pulses is much lower than world average.

The total cultivated area in the world is around 4.9 million hectares producing 4.8 million tonnes with an average production of 1095 kg/ha (FAOSTAT, 2013). Due to mismatch between supply and demand of pulses, price of pulse grain in India have increased exorbitantly during the recent years (Reddy *et al.* 2013). To meet the demand of pulses, India has been recently importing a large quantity of pulses (IIPR, 2011). The import of pulse crop increased from 0.38 million tonnes in 1993 to 3.3 million tonnes in 2011-12 (about nine fold increases) and lentil is one among them. During the post-WTO regime, the export potential of lentil has increased as India is the largest producer of pulses in the world. It implicates the need for wider dissemination of low-cost and sustainable lentil production technologies among the farmers of the potential states of country to meet the growing domestic as well as global demand. Lentil is one of the most important winter legume crops which is grown in rainfed cropping systems, tolerant to drought, and is commonly grown in world (Sarker *et al.* 2003). But average lentil yield in India (758 kg/ha) is far below the world average (1139 kg/ha). There is a need to increase both area and productivity; with improved varieties and matching production technologies, which requires both large scale demonstrations and strong extension to disseminate proven location specific technologies.

MATERIALS AND METHODS

Government of India, (GOI) is implementing need-based programs to increase pulses production from time to time, like Technology Mission on Oilseed and Pulses

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Table 1 Districts, Agro-climatic zones and lentil-based cropping system

Zone	District	Annual rainfall (mm)	Cropping systems
Eastern Himalayan Region (Zone-I)	Nagaon (Assam)	1840-2030	Maize-Lentil-Jute-Urdbean Jute-Winter Rice-Lentil
Lower Gangetic Plains Region (Zone-III)	Malda and Murshidabad (West Bengal)	1300-1600	Maize-Lentil Rice- Lentil- Rice-Chickpea+ Lentil
Middle Gangetic Plains Region (Zone-IV)	Patna, Nalanda and Muzaffarpur (Bihar) and Ballia and Chandauli (Uttar Pradesh)	1200-1470	Rice-Lentil
Upper Gangetic Plains Region (Zone-V)	Fatehpur (Uttar Pradesh)	780-900	Rice-Lentil

Source: Adapted from Lentil-Based Cropping Systems, H.S. Sekhon, Guriqbal Singh, Hari Ram in Lentil: *An Ancient Crop for Modern Times*, (Eds) Shyam S. Yadav, David L. McNeil, Philip C. Stevenson, Pages 107-126: Springer, Zones II does not exist in the target region for this study.

(TMOP), Accelerated Pulse Production Program (A3P) and newly introduced National Food Security Mission (NFSM) on Pulses in 2007-08 onwards. No doubt, there has been a significant increase in production of 18.45 million tonnes (MT) during 2012-13. The NFSM-pulses program has helped Indian farmers to increase area and production by adoption improved varieties and using quality seeds as well as other inputs. Mission was launched to bridge the yield gap in pulses through dissemination of improved technologies and farm management practices with focus on districts which have high potential but low level of productivity performance at present.

Mission has also brought International Organization like ICARDA and ICRISAT to work with Indian National Agricultural Research Systems (NARS) for yield enhancement by sharing their experiences at farm level. This synchronizing effect of CGIAR institutes and NARS partners not only helped Indian farmers in increasing the productivity by bringing the new technology but also enriching the skills of the Indian farmers and scientists by capacity building programmes. In the same endeavour, National food Security Mission-Pulses (NFSM-Pulses) funded project on Lentil entitled "Enhancing Lentil Production for Food, Nutritional Security & Improved Rural Livelihoods" was implemented in nine districts of four zones i.e. Eastern Himalayan Region (Nagaon, Assam) -Zone-I, Lower Gangetic Plains Region (Malda and Murshidabad, West Bengal) -Zone-III, Middle Gangetic Plains Region (Patna, Nalanda and Muzaffarpur (Bihar) and Ballia and Chandauli (Uttar Pradesh)-Zone-IV and Upper Gangetic Plains Region (Fatehpur, Uttar Pradesh)-Zone-V (Table 1). Project led by ICARDA was successfully implemented from active participation of scientists/researchers in National Agricultural Research System (NARS), Non-Governmental Organizations (NGOs) and implementing farmers/traders. Lentil growers were divided into below category of zones, so that comparative picture can be drawn easily, and variation among these zones, in relation to climatic parameters and existing cropping practices.

Demonstrations on lentil were conducted to assess its performance during *rabi* seasons of the years 2010-11, 2011-12 and 2012-13. The total area covered was 1209 ha and total 3344 demonstrations were conducted in the project sites. The data was collected through the Participatory Rural Appraisal (PRA) and structured interview schedule from the selected farmers. Lentil farmers were selected based on their cropping pattern and with the help of local village leaders/representatives of farmers' unions.

Four to six improved lentil varieties per location were introduced in the field of adopted farmers in the *rabi* seasons of 2010-11 to 2012-13. The physical inputs, i.e. seed, fertilizers, insecticides, pesticides and technical advice were provided to farmers from sowing to harvesting, including other location specific technologies. Farmers were keen in learning and farm families were involved in various farm operations; wherever, hired labour was required, farmers arranged at their own. Several workshops, field days, travelling seminar, trainings etc. were organized at the project sites to provide time to time technical guidance to farmers. The yield of supplied improved varieties and local variety of farmers were documented simultaneously.

Technology gap, extension gap and the technology index were worked out (Samui *et al.* 2000) and Dayanand *et al.* (2012) as given below.

Technology gap = potential yield - demonstration yield

Extension gap = demonstration yield - farmers yield

$$\text{Technology index} = \frac{(\text{Potential yield} - \text{Demonstration yield})}{\text{Potential yield}} \times 100$$

Technology and extension gap

The technology gap is the difference between potential yield and yield of demonstration field (Mishra *et al* 2007). Lower the technology gap better will be its adoption. The technology gap observed at farm level is usually attributed to dissimilarity in the soil fertility status, agriculture practices and local climatic situation (Mishra *et al.* 2007). Similar studies were reported by the Singh *et al.* (1996) in mustard and Waris and Reddy (1999) in groundnut, Thakral and Bhatnagar (2002) in chickpea, Dhaka *et al.* (2010) in maize and Kumar *et al.* (2012) in ginger. It was suggested that to minimize the technology gap, farmers need to adopt the scientific package of practices.

The extension gap is the difference between demonstration yield and farmers' yield. To minimize this wider extension gap there is a need to educate the farming community by various extension means, to make them aware about the new varieties of the crop with improved production technologies etc. By following the suggested package of practices farmer can increase the production and productivity of the lentil and reduce the extension gap. Similar findings were also recorded by Sagar and Chandra (2004) in mustard, Chandra (2010) in green gram, Balai *et al.* (2012) in rapeseed-mustard, Rai *et al.* (2012) in barley, Ahmed *et al.* (2013) in Indian mustard and Ojha & Singh (2013) in *kharif* onion.

Technology index (%)

The technology index shows the feasibility of the variety at the farmer's field. Lower the value of technology index less is the gap, and more is the feasibility (Hiremath and Nagaraju 2009). Higher technology index reflected higher gap and thus more efforts are required for transferring proven technology to farmers; and insufficient work of extension services to transfer technology (Dayanand *et al.* 2012).

Socio-economic characteristics of targeted agro-climatic zones

As mentioned in methodology major targeted states were merged in to four agro-climatic zones as these were having common agro-climatic conditions for lentil.

This study was implemented in classified four zone of India. As there are wide inter-stats disparities, in order to make it more representative, it has been merged to targeted zones. Per capita income for all the zones under consideration falls below the national average of 43.92, except for Zone IV, which has the highest. This might be because of the lower population in comparison to other zones.

Classified zones are the typical lentil growing areas of the country and main emphasis was on providing improved package and practices to these farmers. In terms of population, high growth in last ten years (2001-2011) was observed at 25%, 20%, 17% and 14%, in Zone V, Zone IV, Zone III and Zone I, respectively (Table 2). Zone V has the highest population and highest decadal growth of 25%, followed by others. Similarly, rural literacy rate was highest in Zone III.

Significant size of the population was below the poverty line in Zone IV (34%), Zone I (32%), Zone III (29%) and Zone V (20%). One main problem is unavailability of irrigation for pulse, and all the targeted states has less than 24% area of its pulses under irrigation.

RESULTS AND DISCUSSION

Improved and recommended package and practices were compared with the on-going farmer's practices and with approximate adoption rates for them. A technology package was developed which includes different varieties, their seed rate, sowing methods, fertilizer doses, insect-pest measure, weed management etc (Table 3). A comparative picture between the existing practice and recommended practices were recorded and explained below.

Eastern Himalayan Region (Zone-I)

Nagaon district of Asom was taken from Eastern Himalayan Region (Zone-I), total 154.51 ha area was covered with 509 demonstrations from 2010-11 to 2012-13 (3 years). HUL-57, IPL-81, PL-406 and Moitree were supplied to the farmers for cultivation. The average productivity of the demonstration plot was 8.53q/ha which was 39.15% higher over farmers' yield. Variety Moitree gave 51.76% followed by HUL-57 with 43.08% higher yield over local (Table 4). Similar study was done by Tiwari and Tripathi (2014) on chickpea and Kumar *et al.* (2010) on Bajra.

Lower Gangetic Plains Region (Zone-III)

Malda and Murshidabad districts were selected from Lower Gangetic Plains Regions. Total 284.51ha area and 1271 demonstration was conducted in this region. Lentil varieties Moitree, Subrata, Asha, HUL-57, Suvendu and

Table 2 Socio-economic indicators in the targeted zones

Zones	Population (in millions)	Per capita income	Rural literacy rate (per 100 persons)	Share of agriculture in total GSDP (%)	% age below poverty line	Daily wages rate (male)	Daily wages rate (female)	Irrigated area under pulses
Eastern Himalayan Region (Zone-I)	104.09 (25.42%)	14654	43.92	16.63	33.7	205	195	16.2
Lower Gangetic Plains Region (Zone-III)	199.82 (20.23%)	22558	52.53	19.59	29.4	226	191	23.8
Middle Gangetic Plains Region (Zone-IV)	91.35 (13.84%)	36322	63.42	12.00	20.0	231	186	23.4
Upper Gangetic Plains Region (Zone-V)	31.20 (17.07%)			16.52	32.0	242	190	-
All India	1210.19	46117	43.92	14.70	21.9	268	204	18.6

Source: Directorate of Economics & Statistics, DAC & FW, 2015; Figure in parentheses represents decadal growth (%) 2001-2011

Table 3 Comparison of improved package of practices and farmers' practices

Particulars	Lentil		
	Improved package of practices	Farmers' practices	Approx. adoption rates (%)
Variety	HUL-57, Moitree, NDL-1, PL-6, PL-8, Subrata, IPL-81, PL-406, DPL-62, Asha and Suvendu	Local	5-10
Soil testing	Have been done in all locations	Not in practice	
Seed rate	35-40 kg/ha for small seeded and 40-45 kg/ha for bold seeded for normal sowing and 50-60 kg/ha for relay cultivation or late sowing	60-70 kg/ha	15-20
Seed priming	Seed priming is done for better germination. Seeds to be soaked during night for 6-8 hr with natural water, drain out excess water and dry in shade before sowing.	Nil	
Seed treatment	Seed to be treated with Thiram @ 2-3 g/kg seeds or carbendazim @ 1-2 g /kg seed and with insecticide, i.e.chloripyriphos @ 8–10 g /kg seed and rhizobium culture @ of 5 packets/ha.	Nil	
Sowing method	Zero-tillage, line sowing and broadcasting	Broadcasting	20-25
Sowing time	15 October to 15 November preferably. In late sown (as in rice-fallow sowing should be completed by the end of November) but first week of December should be avoided.	October to November (depending on the soil moisture and availability of the field)	30-35
Fertilizer dose	Fertilizer @ 20 kg. N, 40 kg, P_2O_2 and 40 kg K_2O	Nil	10-15
Weed management	Pendimethaline Pre-Emergence @ 1.5 kg a.i./ha was applied immediately after sowing (at sufficient soil moisture level) In case of relay/paira cropping, only post-emergence herbicide, Quizalofop-ethyl (TARGASUPER @ 40-50 g/ha at 15-20 DAS) followed by hand weeding.	Hand weeding	20-15
Urea spray	Foliar spray of 2% Urea just before flowering and repeated after 15-20 days specially when there is lack of atmospheric and soil moisture.	Nil	
Plant protection	8-10 g/l of water Mixture of Carbendazim and Mancozeb and curative application of need based plant protection chemicals	No application of chemicals	10-15

Source: Package and practices of lentil in respective zones.

PL-6 were provided to the farmers. Suvendu and PL-6 were provided for two years only. On an average demonstration plot gave 36.57% higher yield than farmers' practices. Variety PL-6 performed best followed by Moitree, Subrata and Asha with 49.41%, 48.47%, 39.86 and 34.34% higher yield than farmers' yield respectively (Table 4). Singh *et al.* (2007) and Islam *et al*. (2011) observed similar findings.

Middle Gangetic Plains Region (Zone-IV)

In Middle Gangetic Plains Region Patna, Nalanda, Muzaffarpur districts from Bihar state and Ballia and Chandauli districts from Uttar Pradesh were taken for the study. In this zone a total of 1301 demonstrations were conducted in 687.35 ha area. Lentil varieties, i.e. HUL-57, NDL-1, IPL-81 were provided in all three years, whereas PL-6, Moitree, and PL-8 for two years only. On an average demonstration plot have shown 53.33 % higher yield than farmers' practices. An average additional yield of 4.54 q/ha were obtained from the demonstration plot. Highest yield was shown by variety PL-8 followed by NDL-1 with 64.99% and 57.20 %, respectively (Table 4). Similar finding were reported by Gautam *et al*. (2007) and Mishra *et al*. (2009)

Upper Gangetic Plains Region (Zone-V)

Fatehpur comes under Upper Gangetic Plains Region. In this Zone-V HUL-57 and NDL-1 were provided for all three years and DPL-62 and PL-6 were supplied for two years only. On an average demonstration exhibited 61.94% higher yield than farmers' practices. An additional yield of 4.12 q/ha was recorded in demonstration plot over farmers' yield (8.67 q/ha). IIPR, Kanpur's variety DPL-62 have recorded 14.04 q/ha yield which was 61.56% higher than farmers' practices (8.69 q/ha). Variety HUL-57 gave 58.56% higher yield followed by NDL-1 with 56.24% higher yield than local check (Table 4). Similar observations were also recorded by Yadav *et al.* (2007) and Singh *et al.* (2007).

Technology gap and extension gap

Overall, improved varieties with improved practices were shown 48% increase over farmers practice. Among zones, Moitree variety in zone I, PL-6 in Zone III, PL-8 in zone IV and DPL-62 in zone were shown 52% higher yields, 49%, 64% and 61%, respectively (Table 4), over farmer practices. Improved seed emerged to be a major

Table 4 Productivity, technology gap, extension gap and technology index of lentil (2010-11-2013-14)

Zone	District and state	Varieties	Area (ha)	No. of demonstrations	Average yield (q/ha)		Potential yield (q/ha)	% increase	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
					Demonstration	Farmers' yield					
Eastern Himalayan Region (Zone-I)	Nagaon (Assam)	HUL-57	50.69	169	8.80	6.15	22.00	43.09	13.20	2.65	60.00
		IPL-81	40.53	136	7.92	5.90	22.50	34.24	14.58	2.02	64.80
		PL-406	22.46	85	7.94	6.22	20.00	27.65	12.06	1.72	60.30
		Moitree *	40.83	119	9.47	6.24	25.00	51.76	15.53	3.23	62.12
		Total/Average	154.51	509	8.53	6.13	22.37	39.15	13.84	2.40	61.86
Lower Gangetic Plains Region (Zone-III)	Malda and Murshidabad (West Bengal)	Moitree	123.48	611	14.97	10.09	25.00	48 .47	10.03	4.88	40.12
		Subrata	84.69	330	14.21	10.16	20.00	39.86	5.79	4.05	28.95
		Asha	7.17	29	13.34	9.93	18.50	34.34	5.16	3.41	27.89
		HUL-57	42.45	215	12.76	9.77	22.00	30.60	9.24	2.99	42.00
		Suvendu*	8.49	30	11.65	8.94	22.00	30.31	10.35	2.71	47.05
		PL-6*	18.23	56	12.70	8.50	18.00	49.41	5.30	4.20	29.44
		Total/Average	284.51	1271	13.27	9.57	20.92	36.57	7.65	3.70	46.19
Middle Gangetic Plains Region (Zone-IV)	Patna, Nalanda and Muzaffarpur (Bihar) and Ballia and Chandauli (Uttar Pradesh)	HUL-57	245.59	475	12.97	8.35	22.00	55.33	9.03	4.62	41.05
		NDL-1	141.97	247	14.62	9.30	21.00	57.20	6.38	5.32	30.38
		IPL-81	103.69	210	11.44	7.98	22.50	43.36	11.06	3.46	49.16
		PL-6*	107.00	192	13.37	8.69	18.00	53.86	4.63	4.68	25.72
		Moitree*	63.87	144	12.88	8.86	25.00	45.37	12.12	4.02	48.48
		PL-8*	25.23	33	13.15	7.97	20.00	64.99	6.85	5.18	34.25
		Total/Average	687.35	1301	13.07	8.53	21.42	53.33	8.35	4.55	38.96
Upper Gangetic Plains Region (Zone- (Zone-V)	Fatehpur (Uttar Pradesh)	HUL-57	30.06	106	13.70	8.64	22.00	58.56	8.30	5.06	37.73
		NDL-1	13.6	54	13.53	8.66	21.00	56.24	7.47	4.87	35.57
		DPL-62*	18.37	47	14.04	8.69	20.00	61.56	5.96	5.35	29.80
		PL-6*	21.18	56	13.30	8.70	18.00	52.87	9.30	4.60	26.11
		Total/Average	83.21	263	13.64	8.67	20.25	57.31	7.75	4.97	32.30
Grand Total/average			1209	3344	12.39	8.39	21.23	47.68	8.84	4.00	41.64

Source: Field data : Note: * Varieties provided in two years only.

reason for this increase. In rice-fallow situation, variety HUL-57 was best in all the targeted zones.

Despite these impressive yield increase technology, performance of the technology under famers management was much lower that its potential. Potential yields of lentil varieties were taken from respective research institutions and varietal release data. The differences between potential yields and yields of demonstration fields are defined as technology gaps. An average technology gap over three years was estimated at 0.87 tonnes/ha for all zones combined. It was lowest in Zone III with 0.75 tons/ha followed by Zone IV with 0.76 tonnes/ha and highest at Zone I with 1.36 tonnes/ha. Technology gap was lowest recorded in variety PL-6 at Zone IV with 0.45 q/ha followed by Asha with 0.50 tons/ha at Zone III and highest in Moitree with 1.52 tons/ha at Zone I. Technology index is defined as the difference between potential yields and demonstration yields over potential yield in percent terms. It shows feasibility of the variety at farmer's field. The lower the value of technology index more is the feasibility (Hiremath and Nagaraju 2009). Higher technology index reflects the inadequacy of the technology for transferring to farmers and insufficient extension services to transfer of technology (Dayanand *et al*. 2012). The lowest technology index was observed at Zone-V followed by Zone-IV with 32.30% and 38.96%, respectively. The technology index varied from 32.30% (Zone-V) to 61.86% (Zone-I), which is quite a wide gap existing between the potential of technology promoted and technology adopted at farm level. On an average technology index was 41.64%. This wide gap could be, mainly, due to agro climatic conditions and management practices including sowing time, soil health, management of insect-pest and diseases infestations, rate and timing of input applications. From the positive perspective, the technology gap (or technology index as expressed in percentage terms) shows the potential economic advantage of the technology when the farmers adopt the whole package of agronomic practices that accompany the modern varieties. The economic costs and benefits of this adoption would be critical and will be the focus of the next step.

Additionally, the extension gap is defined as the difference between demonstration yield and farmers yield. Extension gap was estimated at 0.39 tons/ha. The differences on the observed technology gaps may be attributed to dissimilarity in the soil fertility status, agriculture practices and local climatic conditions. These productivity gaps can be reduced by enhancing farmers knowledge through more effective extension methods.

Conclusion

It all the project sites, improved varieties showed higher grain yield than farmers' traditional cultivars. There is need to replace traditional varieties and technologies with the improved varieties and production technologies to increase the production at farm level. This will result in increase in income and upgrade the socio-economic level of the farming communities.

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