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

POOJA SAH¹, ATUL DOGRA², ASHUTOSH SARKER³, ADEN AW HASSAN⁴ and AQEEL HASAN RIZVI⁵

South Asia and China Regional Program, ICARDA, New Delhi 110 012, India

Received: 13 April 2018; Accepted: 30 October 2018

**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 Chaudaulia (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
(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 Chaudauli (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.

\[
\text{Technology gap} = \text{potential yield - demonstration yield}
\]

\[
\text{Extension gap} = \text{demonstration yield - farmers yield}
\]

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

**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 Bhattragar (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

---

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

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

| 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%)           |                   |                                      |                                       |                          |                        |                           | -                          |
| 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
LENTIL DEMONSTRATIONS AT FARMERS’ FIELDS

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

| Particulars         | Lentil          | 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. chloropyriphos @ 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. P₂O₅ and 40 kg K₂O | 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 | 10-15 |
| 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 II, 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 (%) |
|-------------------------------|--------------------------------------------------|-----------|-----------|-----------------------|----------------------|------------------------|------------|-----------------------|----------------------|---------------------|
| Eastern Himalayan Region      | Nagaon (Assam)                                   | HUL-57    | 50.69     | 169                   | 8.80                 | 6.15                   | 22.00      | 43.09                 | 13.20                | 60.00               |
|                               |                                                  | IPL-81    | 40.53     | 136                   | 7.92                 | 5.90                   | 22.50      | 34.24                 | 14.58                | 64.80               |
|                               |                                                  | PL-406    | 22.46     | 85                    | 7.94                 | 6.22                   | 20.00      | 27.65                 | 12.06                | 60.30               |
|                               |                                                  | Moitree   | 40.83     | 119                   | 9.47                 | 6.24                   | 25.00      | 51.76                 | 15.53                | 62.12               |
|                               |                                                  | Total/Average | 154.51   | 509                   | 8.53                 | 6.13                   | 22.37      | 39.15                 | 13.84                | 61.86               |
| Lower Gangetic Plains Region  | Malda and Murshidabad (West Bengal)              | Moitree   | 123.48    | 611                   | 14.97                | 10.09                  | 25.00      | 48.47                 | 10.03                | 40.12               |
|                               |                                                  | Subrata   | 84.69     | 330                   | 14.21                | 10.16                  | 20.00      | 39.86                 | 5.79                 | 28.95               |
|                               |                                                  | Asha      | 7.17      | 29                    | 13.34                | 9.93                   | 18.50      | 34.34                 | 5.16                 | 27.89               |
|                               |                                                  | HUL-57    | 42.45     | 215                   | 12.76                | 9.77                   | 22.00      | 30.60                 | 9.24                 | 42.00               |
|                               |                                                  | Suvendu*  | 8.49      | 30                    | 11.65                | 8.94                   | 22.00      | 30.31                 | 10.35                | 47.05               |
|                               |                                                  | PL-6*     | 18.23     | 56                    | 12.70                | 8.50                   | 18.00      | 49.41                 | 5.30                 | 29.44               |
|                               |                                                  | Total/Average | 284.51   | 1271                  | 13.27                | 9.57                   | 20.92      | 36.57                 | 7.65                 | 46.19               |
| Middle Gangetic Plains Region | 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                 | 41.05               |
|                               |                                                  | NDL-1     | 141.97    | 247                   | 14.62                | 9.30                   | 21.00      | 57.20                 | 6.38                 | 30.38               |
|                               |                                                  | IPL-81    | 103.69    | 210                   | 11.44                | 7.98                   | 22.50      | 43.36                 | 11.06                | 49.16               |
|                               |                                                  | PL-6*     | 107.00    | 192                   | 13.37                | 8.69                   | 18.00      | 53.86                 | 4.63                 | 25.72               |
|                               |                                                  | Moitree*  | 63.87     | 144                   | 12.88                | 8.86                   | 25.00      | 45.37                 | 12.12                | 48.48               |
|                               |                                                  | PL-8*     | 25.23     | 33                    | 13.15                | 7.97                   | 20.00      | 64.99                 | 6.85                 | 34.25               |
|                               |                                                  | Total/Average | 687.35   | 1301                  | 13.07                | 8.53                   | 21.42      | 53.33                 | 8.35                 | 38.96               |
| Upper Gangetic Plains Region  | Fatehpur (Uttar Pradesh)                         | HUL-57    | 30.06     | 106                   | 13.70                | 8.64                   | 22.00      | 58.56                 | 8.30                 | 37.73               |
|                               |                                                  | NDL-1     | 13.6      | 54                    | 13.53                | 8.66                   | 21.00      | 56.24                 | 7.47                 | 35.57               |
|                               |                                                  | IPL-62*   | 18.37     | 47                    | 14.04                | 8.69                   | 20.00      | 61.56                 | 5.96                 | 29.80               |
|                               |                                                  | PL-6*     | 21.18     | 56                    | 13.30                | 8.70                   | 18.00      | 52.87                 | 9.30                 | 26.11               |
|                               |                                                  | Total/Average | 83.21    | 263                   | 13.64                | 8.67                   | 20.25      | 57.31                 | 7.75                 | 32.30               |
| Grand Total/average           |                                                 |           | 1209      | 3344                  | 12.39                | 8.39                   | 21.23      | 47.68                 | 8.84                 | 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.

**ACKNOWLEDGEMENT**

We are gratefull to National Food Security Mission-Pulses (NF5M-P), Department of Agriculture Cooperation, Government of India for grant-in-aid to implement the lentil enhancement project. We are also thankful to farmers, who adopted the technologies and provided needed information.

**REFERENCES**

Afzal M A, Hamid Abdul, Bakr M A, Sarker A, Erskine W, Haque M and Aktar M S. 2004. Technology dissemination to boost pulse production and human nutrition in Bangladesh. New directions for a diverse planet: Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, 26 September – 1 October 2004.

Agricultural Statistics at a Glance. 2014. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Economics and Statistics, Oxford University Press.

Ahmad A, Prem G and Kumar R. 2013. Impact of frontline demonstrations on Indian mustard through Improved Technologies. Indian Research Journal of Extension Education 13 (1): 117–9.

Ali M and Gupta S. 2012. Carrying capacity of Indian agriculture: pulse crops. Current Science 102(6): 874–81.

Balai C M, Meena R P, Meena B L and Bairwa R K. 2012. Impact of front-line demonstration on rapeseed-mustard yield improvement. Indian Research Journal of Extension Education 12(2): 113–6.

Bhatti R S. 1988. Composition and quality of lentil (Lens culinaris Medik): a review. Canadian Institute of Food Science and Technology 21: 144-60.

Chandra G. 2010. Evaluation of frontline demonstration of green gram (Vigna radiata L.) in Sundarbars, West Bengal. Journal of Indian Society of Coastal Agricultural Research 28 (1): 12–5.

Dayanand, Verma R K and Mehta S M. 2012. Boosting mustard production through front line demonstrations. Indian Research Journal of Extension Education 12(3): 121–3.

Dhaka B L, Meena B S and Suwalka R L. 2010. Popularization of improved maize production technology through frontline demonstrations in south-eastern Rajasthan. Journal of Agricultural Sciences 1: 39–42.

Gautam U S, Paliwal D K and Naberia Seema. 2007. Improvement of improved maize production technology through frontline demonstrations in south-eastern Rajasthan. Journal of Agricultural Sciences 1: 39–42.

Hiremath S M and Nagaraju M V. 2009. Evaluation of front-line demonstration trials on onion in Haveri district of Karnataka. Karnataka Journal of Agricultural Sciences 22: 1092–3.

Islam Mokidul, Mohanty A K and Kumar Sanjay. 2011. Correlating growth, yield and adoption of urdbean technologies. Indian Research Journal of Extension Education 11(2): 20–4.

Kokate K D, Singh A K and Singh Lakhant. 2013. Harnessing pulses productivity for food and nutritional security. Indian Research Journal of Extension Education 13(1).

Kumar Anil, Kumar Ramesh, Yadav V P S and Kumar Rajender. 2010. Impact assessment of frontline demonstrations of bajra in Haryana state. Indian Research Journal of Extension Education 10(1): 105-8

Kumar Ashok, Avasthe R K, Lepcha B, Mohanty A K and Shukla G. 2012. Impact of front-line demonstrations on yield enhancement
of ginger (var. Majauley) in tribal reserve biosphere of Sikkim Himalaya. **Journal of Agricultural Sciences** 3(2): 121–3.

Meena B L, Meena R P, Meena R H and Balai C M. 2012. Yield gap analysis of rapeseed-mustard through front line demonstrations in agro climatic zone of Rajasthan. **Journal of Oilseed Brassica** 3(1): 51–5

Mishra D K, Paliwal Dinesh Kumar, Tailor R S and Deshwal Alok Kumar. 2009. Impact of frontline demonstrations on yield enhancement of potato. **Indian Research Journal of Extension Education** 9(3): 26–8

Mishra D K, Tailor R S, Pathak Gopesh and Deshwal Alok. 2007. Yield gap analysis of blight disease management in potato through front line demonstration. **Indian Research Journal of Extension Education** 7(2&3): 82–4.

Ojha M D and Singh H. (2013). Evaluation of Technology Dissemination through Demonstration on the Yield of Kharif Onion. **Indian Research Journal of Extension Education** 13(1): 129–131.

Quinn M A. 2009. Biological nitrogen fixation and soil health improvement, the lentil: botany, production and uses. Edited by William Erskine, Fred J Muehlbauer, Ashutosh Sarker and Balram Sharma.

Rai H K, Mughal A H, Sharma V K, Singhal S K and Panday Manoj. 2012. Front line demonstration trial of Barley cv. Nurboo on farmers’ field in cold arid Kargil region of J&K. **Indian Research Journal of Extension Education** 12(2): 55–8.

Sagar R L and Chandra Ganesh. 2004. Frontline demonstration on sesame in West Bengal. **Agriculture Extension Review** 16(2): 7–10.

Sagar R L and Chandra Ganesh. 2004. Evaluation of front line demonstration on mustard in Sunderbans, West Bengal. **Indian Journal of Extension Education** 40(3&4): 96–7.

Samui S K, Maitra S, Roy D K, Mandal A K and Saha D. 2000. Evaluation on front line demonstration on groundnut. **Journal of the Indian Society Costal Agricultural Research** 18(2): 180–3.

Sharma R P and Kushwah S S. 2001. Evaluation of first line demonstration trails in Rajgarh district of Madhya Pradesh. **Agricultural Science Digest** 21(3): 182–5.

Shyam S Yadav, David L McNeil, Philip C Stevenson. 2007. Lentil: an ancient crop for modern times. Springer Science & Business Media.

Singh D K, Gautam U S and Singh R K. 2007. Study on yield gap and level of demonstrated crop production technology in Sagar district. **Indian Research Journal of Extension Education** 7(2&3): 94–5.

Singh Trilochan, Vyas M D, Saxena A and Jain Anil. 2007. Impact of new technologies on soybean at farmers’ field. **Indian Research Journal of Extension Education** 7(1): 39–40.

Singh M P, Chauhan K N K and Amtilawari S. 1996. Correlates of knowledge, attitude and risk performance of farmers towards dry farming technology. **Maharashtra Journal of Extension Education** 8: 146–249.

Singh S N, Singh V K, Singh R K and Singh Rakesh K. 2007. Evaluation of on-farm front line demonstrations on the yield of mustard in central plains zone of Uttar Pradesh. **Indian Research Journal of Extension Education** 7(2&3): 79–81.

Thakral S K and Bhatnagar P. 2002. Evaluation of frontline demonstration on chickpea in north-western region of Haryana. **Agricultural Science Digest** 22(3): 217–8.

Tiwar B K and Tripathi P N. 2014. Yield gap analysis of chickpea (Cicer arietinum) through front line demonstration on farmers’ fields. **Journal of Rural and Agricultural Research** 14: 5–8.

Waris A and Reddy M S. 1999. Technological gap in adoption of groundnut production technology. **Maharashtra Journal of Extension Education** 18: 268–9.

Yadav V P S, Kumar R, Deshwal A K, Raman R S, Sharma B K and Bhela S L. 2007. Boosting pulse production through frontline demonstration. **Indian Research Journal of Extension Education** 7(2&3): 12–4.