ABSTRACT

Improved technological interventions are important to sustain production and productivity of rice. A study was conducted by Regional Rainfed Lowland Rice Research Station, ICAR–National Rice Research Institute, Gerua, Kamrup in four districts of lower Brahmaputra valley and north bank plains agro-climatic zones of Assam during boro seasons from 2012–13 to 2016–17 to enhance productivity of boro rice through introduction of latest rice varieties and application of improved production technology. Performance of open-pollinated varieties, viz. Naveen, Chandrama and CR Dhan 909, and hybrids, viz. Ajay and Rajalaxmi under application of improved production technology were demonstrated. At all the locations, application of improved technologies showed superior results in terms of growth, yield attributes, productivity and profitability over local checks under farmers’ practice. Rice varieties with application of improved production technologies, increased mean grain yield by an average of 38.8% and extra earning of Rs 18137/ha over existing farmer’s practice with only Rs 3632/ha extra expenditure on inputs. The mean gap indices, viz. extension gap (1.56 t/ha), technology gap (0.96 t/ha), technology index (14.5%) and mean B:C (4.99) clearly indicated the superiority of technological demonstrations over farmers’ practices. The study also lays emphasis on the framing intensive technology transfer programmes like technological demonstrations on field to motivate the farmers for higher adoption rate of improved rice production technology.

Key words: Boro rice, Front line demonstrations, Improved production technology, Productivity, Profitability, Rice varieties
of rice farmers through technological interventions of high yielding rice varieties with recommended package of practices and (ii) to analyse the technological gaps in rice farming in the region.

MATERIALS AND METHODS

FLDs on high yielding rice varieties along with improved production technology were conducted on 289 farmers’ fields covering 115 ha area in 14 villages of four districts of Assam, viz. Champupara Pathar and Laruajan of Kamrup; Galdighala, Ghoga, Burlutpar, Sunger Bari and Mukhkuchi of Nalbari; Geladingi, No. 2 Mazgaon, Naogaon and Gorakhat of Darrang; Hokradoba, Luisgaon,Puroni Hapagaon of Udalguri from 2012–13 to 2016–17 in partially irrigated lands in boro season. The climate of the region is characterised by heavy monsoon downpours reducing summer temperatures and affecting foggy nights and mornings in winters whereas, moderate rainfall and temperature during spring (March-April) and autumn (September-October). The soils of the region are light black to sandy clay loam in texture, low in available N and P and medium in available K. The constraints in rice production in the region were identified through participatory rural appraisal, farmer meetings and training programmes, field survey and field diagnostic visits during crop growth period in the previous years following the procedures as followed by Choudhary and Rahi (2018) and Choudhary and Suri (2018a). It was found that the low yield of rice conceived is due to lack of suitable medium-duration rice variety, imbalanced use of fertilizers, aged seedling, infestation of weeds and improper crop geometry. Based on the problems identified, FLDs were conducted at farmer’s field while using high yielding rice varieties, viz. Chandrama, Naveen and CR Dhan 909 and hybrids, viz. Ajay and Rajalaxmi. The most important characteristics of rice varieties and hybrids are depicted in Table 1. The plot size under each demonstration was 0.2 to 0.4 ha. Seed @ 30 kg/ha, fertilizers @ 80:40:40 kg/ha N–P₂O₅–K₂O and pre-emergence herbicide (Pretilachlor) @ 1.0 kg a.i/ha were provided to the farmers’ as critical inputs with improved crop production technologies as intervention during the course of FLD programme. The seeds were treated with Carbendazim @ 2 g/kg seed. Nursery was raised between last week of December and second week of January in

| Cultivar     | Pedigree/parentage                     | Source                                      | Characteristics                                                                                                                                 |
|--------------|----------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Naveen       | Sattari/Jaya cross                     | ICAR-National Rice Research Institute, Cuttack | Semi-dwarf plant type (100 to 115 cm) with 10-15 bearing tillers and long panicle (24-25 cm). Resistant to blast, gall midge biotype 5 and 1 and stem borer, and tolerant to brown spot disease. Medium bold grain size with 66.5% head rice recovery and elongation ratio of 1.76. Matures in 120 days (kharif/sali); 145-150 days (boro/ahu) |
| Chandrama    | ARC 6650/CR 94-721-3                   | ICAR-National Rice Research Institute, Gerua, Asom | Semi-dwarf plant type (105 to 115 cm) with 12-15 bearing tillers and long panicle (22-25 cm). Tolerant to leaf and neck blast, bacterial leaf blast, rice tungro disease and sheath blight. Cold tolerant during vegetative stage Matures in 135–140 days (kharif/sali); 170–175 days (boro/ahu) Medium bold grain size with 67% head rice recovery. Potential yield >5 t/ha (sali/kharif); 6.5–7 t/ha (ahu/boro season) |
| CR Dhan 909  | Pankaj/Padumoni                        | ICAR-National Rice Research Institute, Gerua, Asom | Suitable for rainfed shallow lowland and irrigated ecology Aromatic short grain Matures in 135–140 days (kharif/sali) Potential yield 4.5–5.5 t/ha (sali/kharif) |
| Ajay (Hybrid)| CRMS 31 A x IR 42266-29-3R             | ICAR-National Rice Research Institute, Cuttack | Medium tall plants (110-115 cm) Duration: 125–130 days (sali); 155-160 days (Boro) Long panicle, spikelet fertility >85%, long slender grains Good milling (62%), cooking and eating quality Tolerant to leaf blast, brown leaf blight and stem borer Potential yield 5–6 t/ha (sali/kharif); 6.5–7.5 t/ha (ahu/boro) |
| Rajalaxmi (Hybrid) | CRMS 32 A x IR 42266-29-3R     | ICAR-National Rice Research Institute, Cuttack | Medium tall plants (110–115 cm) Duration: 125–130 days (sali); 155-160 days (boro) Long panicle, spikelet fertility >87%, long slender grains Good milling (60%), cooking and eating quality Tolerant to leaf blast, brown leaf blight and stem borer Potential yield 5–6 t/ha (sali/kharif); 6.5–7 t/ha (ahu/boro) |
boro season every year. Rice seedlings of 40–45 days were transplanted in the field during second fortnight of February every year. The FLDs were regularly monitored from nursery raising to harvesting. In case of local check (control plots), existing farmers’ practices were followed (Table 2). Recommended dose of fertilizers were applied as urea, di-ammonium phosphate, and muriate of potash. Full dose of P\textsubscript{2}O\textsubscript{5} 1/3\textsuperscript{rd} of N and 3/4\textsuperscript{th} of K\textsubscript{2}O was applied as basal at the time of transplanting. Remaining N was applied in 2 equal splits at maximum tillering and panicle initiation stages, 1/4\textsuperscript{th} of K\textsubscript{2}O was applied as top-dressing at panicle initiation. A thin film (2-5 cm) of water was maintained during dry period of February-March and April onwards frequent pre-monsoon showers met the water requirement of crop almost every year.

An off-campus training programme was organized before conducting the demonstrations for the selected farmers of the respective villages to impart technological knowledge on improved rice production techniques. All other steps like site selection, layout of demonstrations, farmers’ participation etc. were followed as suggested by Choudhary and Suri (2014a, 2014b). The observations on plant growth and yield attributes were recorded from 10 representative hills from five different locations of five farmers’ fields from each village (Rana et al. 2014). Grain yield of demonstrations and farmers’ practice were recorded through crop cutting technique from net plot size of 25 m\textsuperscript{2} area of five farmers’ fields of each location following standard procedures as suggested by Rana et al. (2014). The crop was harvested between last week of May and second fortnight of June every year. The various indices of gap analysis were derived from the grain yield and economic returns as suggested by Choudhary and Suri (2014a, 2014b) and Yadav et al. (2015). The details of these indices are given below:

- Technology gap (t/ha) = Potential yield (P\textsubscript{1}) – Demonstration yield (D\textsubscript{1})
- Extension gap (t/ha) = Demonstrated yield (D\textsubscript{1}) – Farmer’s practice yield (F\textsubscript{1})
- Technology index (%) = (P\textsubscript{1} – D\textsubscript{1})/P\textsubscript{1} × 100
- Additional return (\$/ha) = Demonstrated return (Dr) – Farmer’s practice return (Fr)
- Effective gain (\$/ha) = Additional return (Ar) – Farmer’s practice return (Fr)
- Benefit cost ratio (B : C) = Additional return (Ar)/Additional cost (Ac)

RESULTS AND DISCUSSION

Maturity, growth and yield attributes: The maximum demonstrations (171) were of Naveen variety covering 70 ha area followed by Chandrama. The main reason of having more demonstrations on Naveen was due to its suitability in the region as it took minimum duration in maturity, i.e. 152 days and harvested in the last week of May every year which helps escape the crop from early flash floods at time of maturity. Chandrama with farmers’ practice generally suffered flooding during harvesting in the mid-June at Nalbari and Kamrup districts demonstrations. Chandrama and local checks of farmers practice took the maximum duration (165–168 days) in maturity followed by the hybrids. But it was observed that if Chandrama was transplanted between the last week of January and first week of February, it resulted in highest grain yield and also escaped from flash floods. The maximum plant height (124.3 cm) was recorded in CR Dhan 909 followed by Rajalaxmi and Chandrama, respectively. However, local checks recorded minimum plant height. The average values of the yield attributing characteristics, i.e. number of tillers,

| Particulars          | Technological interventions in demonstrations                                      | Farmers practice                                      | Technology gap |
|----------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------|----------------|
| Farming situation    | Well irrigated and light black to sandy clay loam                                | Well irrigated sandy clay loams                       | No gap         |
| Land preparation     | 3–4 ploughings                                                                   | 3–4 ploughings                                        | No gap         |
| Fertilizer doses (kg/ha) | 80:40:40 (N–P\textsubscript{2}O\textsubscript{5}–K\textsubscript{2}O)          | 60:30:20 (N–P\textsubscript{2}O\textsubscript{5}–K\textsubscript{2}O) | Partial gap   |
| Variety              | Naveen, Chandrama, Ajay, Rajalaxmi and CR Dhan 909                               | Luit and Baismuthi China boro (Local)                | Full gap       |
| Seed rate (kg/ha)    | 30.0                                                                              | 45–50                                                 | Higher         |
| Seed treatment       | Bavistin @ 2g/kg seed                                                             | Nil                                                   | Full gap       |
| Age of seedlings     | 40 days (boro)                                                                    | 70–80 days (boro)                                     | Higher         |
| Planting method      | Line transplanting (20 × 15 cm)                                                  | No line transplanting                                 | Full gap       |
| Plant population (m\textsuperscript{2}) | 34 hill                                                                         | 45–48                                                 |                |
| Weed management      | Pre-emergence Pretilachlor @ 1.0 kg a.i./ha                                      | Partial one hand weeding at 40–50 days after transplanting | Partial gap   |
| Plant protection     | Need based application of Carbofuran 3G @ 25 kg/ha                                | No plant protection measures                          | Full gap       |
| Water management     | Maintain thin film of water up to panicle initiation (mention depth)             | Flooding during the crop growth period and irrigation water at flowering stage | Partial gap    |
Table 3 Growth and yield attribute of rice varieties under front line demonstrations and local checks (average of all locations over the years)

| Variety         | No. of demonstrations | Area (ha) | Yield potential (t/ha) | Maturity duration (days) | Plant height (cm) | Panicle length (cm) | Filled grains/panicle | Unfilled grains/panicle |
|-----------------|-----------------------|-----------|------------------------|--------------------------|-------------------|---------------------|------------------------|------------------------|
| Naveen          | 171                   | 70        | 6.5                    | 152                      | 114.6             | 419.7               | 25.7                   | 131.85                 | 27.2                   |
| Chandrama       | 51                    | 18        | 6.5                    | 168                      | 115.2             | 399.4               | 25.5                   | 149.2                 | 22.6                   |
| CR Dhan 909     | 21                    | 7         | 6.0                    | 155                      | 124.3             | 366.5               | 25.3                   | 136.4                 | 23.6                   |
| Ajay (Hybrid)   | 25                    | 10        | 7.5                    | 160                      | 112.5             | 416.2               | 25.6                   | 158.2                 | 23.6                   |
| Rajalaxmi (Hybrid) | 21                | 10        | 7.0                    | 160                      | 116.2             | 408.5               | 25.8                   | 152.8                 | 21.9                   |
| Local checks    | -                     | -         | -                      | -                        | -                 | -                   | -                      | -                      |

The productivity of 0.70 t/ha was recorded during the 2012–13 season whereas, during 2016–17 minimum grain yield of 5.1 t/ha and 3.4 t/ha was recorded with Naveen followed by Ajay and Rajalaxmi hybrids, respectively. However, panicle length of all demonstrated varieties was almost similar except CR Dhan 909. Both hybrids recorded higher number of filled grains per panicle and lower unfilled grains per panicle which was closely followed by Chandrama. Whereas, Naveen recorded lower number of filled grains per panicle and higher number of unfilled grains per panicle but higher number of tillers per m² might have compensated the grain yield. Local checks in farmers’ practice recorded the minimum values of tillers, panicle length, filled and unfilled grains per panicle which resulted in lower grain yield. The differences in growth and yield attribute parameters might be due to varietal characteristics (Jiang, et al. 2007). However, all demonstrated varieties were found superior in terms of growth and yield attributes over local checks of farmers’ practice. Choudhary and Suri (2014a, 2014b) and Yadav et al. (2015) also recorded higher values for growth and yield attributes from demonstrations over local controls in various crops.

**Grain yield and gap analysis:** The productivity of demonstrated rice varieties with improved production technology ranged from 5.1 to 6.2 t/ha with overall 5.6 t/ha whereas, local checks of farmers’ practices recorded grain yield from 3.4 to 4.4 t/ha with overall mean of 4.1 t/ha (Table 4). The maximum grain yield of 6.2 t/ha and 4.4 t/ha was recorded during 2012–13 season whereas, during 2016–17 minimum grain yield of 5.1 t/ha and 3.4 t/ha was obtained from demonstrations and local checks of farmers’ practices, respectively. It was mainly due to favourable weather parameters and rice hybrids in 2012–13. The yield advantage over farmers’ practice ranged from 28.6 to 50.8% with an overall mean of 38.8% which proved the superiority of demonstrations with improved production technologies over local farmers’ practices. These results are in corroboration with the findings of Yadav et al. (2015) and Rahi and Choudhary (2014, 2016). Increase in grain yield might be attributed to optimum utilization of all the production factors in the demonstrations accelerating better growth and yield parameters (Choudhary et al. 2010; Seema et al. 2014; Choudhary and Rahi 2018). The results of the demonstrations clearly indicate the impact of FLDs over the farmers’ practices towards enhancing the yield of rice in rainfed lowland ecology of Assam (Choudhary and Suri 2014a, 2014b).

An extension gap of 1.19 to 1.83 t/ha in grain yield was found between demonstrated technology and farmers’ practices during various years. The average extension gap of 1.56 t/ha was noticed which might be attributed to rice varieties and adoption of improved production technology in the demonstration plots which resulted in higher grain yield than the existing farmers’ practices (Choudhary and Suri 2018a, 2018b). Higher values of extension gap emphasized to convince the farmers to adopt improved production technologies alongside latest rice varieties to achieve higher productivity and profitability (Choudhary and Suri 2013, 2018a). The technology gaps ranged from 0.7 to 1.2 t/ha with overall average of 0.96 t/ha which indicates 14.5% lower grain yield of mean yield potential of

Table 4 Grain yield and gap analysis of improved technological demonstrations on rice at farmers’ field (average of all rice varieties)

| Year   | Potential yield (t/ha) | Demonstrated yield (t/ha) | Farmers’ practice yield (t/ha) | Increase over Farmers’ practices (%) | Extension gap (t/ha) | Technology gap (t/ha) | Technology index (%) |
|--------|------------------------|---------------------------|-----------------------------|-------------------------------------|---------------------|----------------------|---------------------|
| 2012-13| 7.0                    | 6.2                       | 4.4                         | 41.7                                | 1.83                | 0.80                 | 11.3                |
| 2013-14| 6.5                    | 5.3                       | 4.2                         | 28.6                                | 1.19                | 1.20                 | 17.9                |
| 2014-15| 6.5                    | 5.6                       | 4.3                         | 33.6                                | 1.42                | 0.90                 | 13.5                |
| 2015-16| 6.5                    | 5.8                       | 4.2                         | 39.4                                | 1.64                | 0.70                 | 10.8                |
| 2016-17| 6.3                    | 5.1                       | 3.4                         | 50.8                                | 1.70                | 1.20                 | 19.2                |
| Average| 6.6                    | 5.6                       | 4.1                         | 38.8                                | 1.56                | 0.96                 | 14.5                |

---

**Table 4**, July 2019, ENHANCEMENT OF BORO RICE PRODUCTIVITY AND PROFITABILITY, 1129
rice varieties. The minimum technology gap (0.7 t/ha) was obtained during 2015-16 whereas the maximum values of technology gap was estimated during 2013–14 and 2016–17 which indicates that local climate was more favourable in 2015–16 than that of 2013–14 and 2016–17. The variability in the technology gap might be due to variability in soil fertility, variability in adoption of crop management practices and local climatic conditions while minimum technology gap showed proper adoption of technology and favourable local climatic conditions (Paul et al. 2011; Yadav et al. 2015). Technology index is also very important index which indicates the feasibility of the demonstrated improved technology at farmer’s field (Choudhary and Suri 2014a, 2014b). The technology index varied from 10.8 to 19.2% during course of study. On an average, technology index observed was 14.5% which indicates the efficacy of all rice varieties and technological interventions (Pooniya et al. 2015). Higher technology indexes (19.2% and 17.9%) during 2016–17 and 2013–14 reflected the inadequate efficacy of rice varieties and technological interventions while lower technology indexes (10.8% and 11.3%) during 2015-16 and 2012-13 showed the feasibility of the technology, respectively (Choudhary and Suri 2014a, 2014b). Similar findings on extension gap, technology gap and technology index for field demonstrations were also reported by Yadav et al. (2015) and Rahi et al. (2014, 2016).

Economic analysis: The economic viability of improved production technology over farmers’ practices was calculated on the basis of prevailing price of input and output cost (Table 5). It was observed that the cost of rice production under improved production technologies ranged from ₹ 45470 to 48150/ha with an average of ₹ 47008/ha as against ₹ 41550 to 44800/ha with an average of ₹ 43376/ha under local check of farmers’ practices. The improved production technologies incurred an additional cost of production ranged from ₹ 2720 to 5970/ha with an average of ₹ 3632/ha over local check. The total cost of production (₹47520/ha) and additional cost of production (₹5970/ha) of demonstrations was at higher side during 2012–13 which was mainly due to higher cost of hybrid seeds. The gradual increment in the cost of production was due to increase in input costs and labour wages. The average additional cost (₹3632/ha) increased additional returns (₹18137/ha). The maximum values of total returns, net returns, additional returns and effective gain were calculated for 2015–16 season. However, minimum values for same were recorded during 2013–14 which was due to yield differences in the respective season. The maximum B:C ratio (7.39) was calculated during 2016–17 which might be due to better performance of demonstrations under stress conditions as compared to local check of farmers’ practices. Nirmala and Muthuraman (2009) and Yadav et al. (2015) also reported that adoption of latest varieties alongwith improved production interventions by the farmers in rice resulted in higher economic returns.

Extension and feedback mechanism: The present study revealed that cultivation of rice with improved technologies has been found more productive and grain yield might have

Table 5 Economic analysis of improved technological demonstrations on rice (average of all varieties)

| Year   | Cost of production (₹/ha) | Sale price (MSP) of rice grains (₹/t) | Total Returns (₹/ha) | Net Returns (₹/ha) | Additional return (₹/ha) | Effective gain (₹/ha) | B:C |
|--------|---------------------------|--------------------------------------|----------------------|-------------------|-------------------------|----------------------|-----|
| 2012–13| 47520                     | 47008                                | 77625                | 54792             | 30006                   | 12500                | 2.82|
| 2013–14| 45470                     | 47008                                | 78825                | 54505             | 30006                   | 12500                | 4.71|
| 2014–15| 46550                     | 47008                                | 79025                | 54205             | 30006                   | 12500                | 4.09|
| 2015–16| 47350                     | 47008                                | 79225                | 54005             | 30006                   | 12500                | 4.99|
| 2016–17| 48150                     | 47008                                | 80425                | 53805             | 30006                   | 12500                | 4.79|
| Average| 47008                     | 47008                                | 80000                | 53405             | 30006                   | 12500                | 4.99|
increased due to rice varieties and timely and balanced use of inputs. To strengthen the research, the feedback from farmers was taken during the course of study. Most of the farmers liked the rice varieties along with improved production technology as most of the varieties were high yielding and of medium duration in comparison to their own local varieties. Among the varieties, Naveen was highly appreciated as it is shorter in duration and has slight drought tolerant characteristics. Timely weed management through pre-emergence herbicide and fertilizer management are highly appreciated by the farmers. During the course of study, 8 field days were organized at different locations involving all line departments for further extension of technology. The main indirect outcome of these demonstrations was the use of major part of the produce (except in case of hybrids) as seed. Institute also facilitated farmers to get their seed certified from Asom State Seed Certification Agency. Farmers sold their produce as certified seed to Asom State Seed Corporation and to the local farmers. Thus, intensive extension methodologies led to better technology adoption among the farmers in the study area (Choudhary et al. 2013; Choudhary and Suri 2018a; Choudhary and Rahi 2018).

It can be concluded that cultivation of recent and high yielding rice varieties with improved production technology may reduce the extension and technology gaps among practising farmers to a considerable extent and thus, may lead to increased rice productivity in the region. With adoption of improved production technologies, farmers can increase their rice grain yield by 38.8% with an additional return of ₹18137/ha by incurring additional cost of ₹3632/ha on the improved production technology/inputs. The high extension gap also laid emphasis on motivating the farmers to adopt latest rice varieties coupled with improved rice production technology in the region. Thus, the FLD programme is highly effective extension tool in changing the attitude, skills and knowledge of resource-poor farmers and motivating them to adopt the improved package of practices of high yielding rice varieties.

REFERENCES
Choudhary A K and Rahi S. 2018. Organic cultivation of high yielding turmeric (Curcuma longa L.) cultivars: A viable alternative to enhance rhizome productivity, profitability, quality and resource-use efficiency in monkey–menace areas of north-western Himalayas. Industrial Crops and Products 124: 495–504.
Choudhary A K and Suri V K. 2013. ‘On-farm’ participatory technology development effects on resource conservation technologies in rain-fed upland paddy in Himachal Pradesh, India. Communications in Soil Science and Plant Analysis 44(17): 2605–17.
Choudhary A K and Suri V K. 2014a. Frontline demonstration programme – An effective technology transfer tool for adoption of oilseeds production technology in Himachal Pradesh, India. Communications in Soil Science and Plant Analysis 45(11): 1480–98.
Choudhary A K and Suri V K. 2014b. Scaling-up of pulse production under frontline demonstration technology transfer program in Himachal Himalayas, India. Communications in Soil Science and Plant Analysis 45(14): 1934–48.
Choudhary A K and Suri V K. 2016. Integrated crop management practices for off-season cabbage in high-hill wet-temperate region of north-western Himalayas. Annals of Agricultural Research 37(4): 406–09.
Choudhary A K and Suri V K. 2018a. System of rice intensification in short duration rice hybrids under varying bio-physical regimes: New opportunities to enhance rice productivity and rural livelihoods in north-western Himalayas under a participatory-mode technology transfer program. Journal of Plant Nutrition. Published online DOI:10.1080/01904167.2018.1510515.
Choudhary A K and Suri V K. 2018b. System of rice intensification in promising rice hybrids in north-western Himalayas: Crop and water productivity, quality and economic profitability. Journal of Plant Nutrition 41(8): 1020–34.
Choudhary A K, Singh A and Yadav D S. 2010. ‘On farm testing’ of wheat cultivars for site-specific assessment under varied bio-physical regimes in mid-hill conditions of Mandi district of Himachal Pradesh. Journal of Community Mobilization and Sustainable Development 5(1): 1–6.
Choudhary A K, Thakur S K and Suri V K. 2013. Technology transfer model on integrated nutrient management technology for sustainable crop production in high value cash crops and vegetables in North-Western Himalayas. Communications in Soil Science and Plant Analysis 44(11): 1684–99.
Dass A, Chandra S, Choudhary A K, Singh G and Sudhishri S. 2016. Influence of field re-ponding pattern and plant spacing on rice root-shoot characteristics, yield, and water productivity of two modern cultivars under SRI management in Indian Mollisols. Paddy and Water Environment 14(1): 45–59.
GOI.2011. State-wide area, production and productivity of rice during 2006-07 to 2010-11. Directorate of Rice Development, Ministry of Agriculture, Government of India.
GOI.2017. Statistical Year Book India 2017. Ministry of Statistics and Programme Implementation, Government of India.
Harish M N, Choudhary A K, Singh Y V, Pooniya V and Das A, Vararatharajan T and Babu S. 2017. Effect of promising rice (Oryza sativa L.) varieties and nutrient management practices on growth, development and crop productivity in eastern Himalayas. Annals of Agricultural Research 38(4): 375–84.
Jiang W, Strik P C, Lingna J, van Keulen H, Ming Z and Stomph T J. 2007. Uptake and distribution of root-applied or foliar applied 65Zn after flowering in aerobic rice. Annals of Applied Biology 150: 383–91.
Nirmala B and Muthuraman P. 2009. Economic and constraints analysis of rice cultivation in Kaithal District of Haryana. Indian Research Journal of Extension Education 9(1): 47–49.
Paul J, Suri V K, Sandal S K and Choudhary A K. 2011. Evaluation of targeted yield precision model for soybean and toria crops on farmers’ fields under sub-humid sub-tropical North-Western Himalayas. Communications in Soil Science and Plant Analysis 42(20): 2452–60.
Pooniya V, Choudhary A K, Dass A, Bana R S, Rana K S, Rana D S, Tyagi V K and Punjia M M. 2015. Improved crop management practices for sustainable pulse production: An Indian perspective. Indian Journal of Agricultural Sciences 85(6): 747–58.
Rahi S and Choudhary A K. 2014. On-Farm participatory technology development on integrated nutrient management for enhanced crop and rainwater productivity in garlic (Allium sativum L.) in north–western Himalayas. Journal of
Singh U P. 2002. Boro rice in eastern India. Regional technical coordination committee meeting of rice-wheat consortium, 10–14 Feb., 2002, New Delhi, India. pp 2.

Yadav D S, Choudhary A K, Sood P, Thakur S K, Rahi S and Arya K. 2015. Scaling-up of maize productivity, profitability and adoption through frontline demonstration technology-transfer programme using promising maize hybrids in Himachal Pradesh. Annals of Agricultural Research 36(3): 331–38.

Rana K S, Choudhary A K, Sepat S, Bana R S and Dass A. 2014. Methodological and Analytical Agronomy. Post Graduate School, Indian Agricultural Research Institute, New Delhi, India. pp 276.

Seema, Maya K and Devi M T T. 2014. Effect of nitrogen and weed management on nutrient uptake by weeds under direct seeded aerobic rice. The Bioscan 9(2): 535–37.