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POLICY BRIEF

Driving Factors Behind the Adoption of Improved Technologies by Lentil Growers in West Bengal

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Over the last six decades in India, there has been an unsatisfactory gain in pulse productivity, which is a severe threat to the creation of resilient livelihoods and the overall food and nutritional security of the country. To specifically enhance lentil productivity under rice-based cropping systems in West Bengal, the International Centre for Agriculture Research in the Dry Areas (ICARDA) began a multi-disciplinary project in 2012/13 providing improved technologies, including 29 improved lentil varieties, and a package of agronomic practices to farmers.

This policy brief documents the major constraints lentil growers have faced in adopting ICARDA's improved lentil varieties, and increasing their knowledge, skills, and good practices. It also outlines suitable policy recommendations and identifies strategic actions to enhance the adoption and scalability of ICARDA's improved lentil varieties in West Bengal to boost the productivity of farmers.

The study found that years of farming experience, along with a basic education level, were the prime contributors behind the overall adoption of new technology and quality seeds. Meanwhile, the unavailability of suitable and timely information brochures, pamphlets, leaflets, and news for growers meant that a significant proportion of farmers are still unaware about the new varieties and modern technology. One of the key recommendations to encourage uptake is to offer crop insurance to lentil farmers, to protect them from losses resulting from natural calamities, and boost their risk-bearing ability.

Key messages

- The introduction of ICARDA's region-specific improved seeds, and package of practices, for lentil producers, has had a positive economic impact in West Bengal since 2012/13.
- The most popular of ICARDA's varieties were Moitreyee, followed by Bari-7, PL-6 and HULL-57.
- Lentil productivity increased by 36% for farmers involved in ICARDA's project, with effective land preparation, use of quality seed, and implementation of better pest and disease management being the prime factors behind this success.
- Raising the productivity of lentils has benefitted farmers economically in West Bengal.
- Years of farming experience and basic education level were found to be the prime contributors to farmers adopting ICARDA's improved seeds and practices, which enhanced the technical efficiency of farming families.
- An increased producer price for lentils in West Bengal is good news, but most of the profit is going to middlemen.
- The cost benefit ratio was 1.25 for ICARDA's growers, and 0.74 for traditional growers.

1. Introduction

Lentil is one of the most nutritious cool season food legume crops produced in India. Between 2012/13, when the ICARDA project began to be implemented, the crop was grown on 1.14 million ha and 0.86 million tons was produced, resulting in a productivity rate of 756.2 kg/ha (DES, 2013-14). Almost half of the world's lentil production (48.2%) is cultivated in Southern Asia, but indigenous lentils in India are a specific ecotype (a genetically distinct geographic variety) with a marked lack of genetic variability, poor germination rates and yields. In India, the indigenous varieties are primarily grown in northern and central regions, and both whole and dehulled lentils are used to make *dal* (a traditional dish), as well as other culinary preparations (Reddy, Bantilian and Mohan, 2013).

Lentils contain about 25% protein, 0.7% fat, 2.1% minerals, 0.7% fiber and 59% carbohydrate. It is generally grown as a rainfed crop and, in West Bengal, the seeds are broadcast in a rice crop, seven to ten days before the rice is harvested (also known as *paira* cropping or relay cropping), to capitalize on the residual moisture in the soil, and ensure timely sowing and germination as tillage operations can be skipped.

There is tremendous potential to grow lentil as a cool season food legume in West Bengal, but productivity levels are low. Despite pulse production increasing by 3.45% per annum during 2000-10, before ICARDA intervened, India ranked ninth in lentil productivity globally during the same period. Increases in production costs, and supply constraints also pushed lentil prices so high that they became unaffordable for most consumers. Increased lentil demand resulted in the Indian Government having to import between 3-4 million tons of lentils every year.

To achieve self-sufficiency in all pulse crops by 2025, an estimated 27.5 million tons needs to be produced each year. In addition to reducing post-harvest losses, productivity also needs to be enhanced from 897 kg/ha in West Bengal (DES, 2020/21) to 1,000 kg/ha, and an additional area of about 3-4 million ha needs to be brought under pulses (Ali and Kumar, 2005; ICAR, 2014-15). Achieving these ambitious aims will require a proactive strategy from researchers, planners, policymakers, extension workers, the private sector, and farmers to boost productivity and reduce production costs.

2. Constraints of lentil cultivation in West Bengal

- **Delayed sowing**: In general, lentil crop yields are drastically reduced when sowing is delayed beyond November. Many areas in West Bengal cultivate long duration *kharif* rice varieties, which often keep the land occupied until the middle to end of November, which then delays sowing of lentils. Excessive soil moisture due to untimely rains during November and December can also further delay sowing until mid-December.
- **Weeds**: Lentils have slow vegetative growth in the early stages of crop growth and are a poor competitor to weeds (Siddique et al., 2012; Singh, Shahi and Singh, 2017). Adoption of zero tillage, conservation agriculture-based technologies, and *paira* cropping further intensifies weed growth. These agronomic practices involve minimal to no soil disturbance and, as a consequence, weed seeds remain largely on the soil surface competing with the lentils for natural resources. The extent of yield reduction in lentil due to weed infestation has been reported to be as high as 50% (Rana et al., 2016), implying the severity of weed-induced losses, which could mean that in conservation agriculture-based systems the losses could be even higher.
- **Unavailability of quality inputs**: A lack of good quality and affordable seeds is a major constraint. Not only does this lack of access limit production (traditional varieties yield between 500-600 kg/ha, while high-yielding seeds can reach up to 1,500 kg/ha), but it is also one of the principal reasons behind crop failure (poor germination rates coupled with poor management practices). Timely availability of quality chemical fertilizers also continues to be a problem in many lentil-growing areas. While availability of pesticides (including herbicides) in West Bengal has been reasonable, they are often of a poor quality and are not as effective which means more quantities are applied, which is detrimental to human and crop health.
- **Technological constraints**: Legumes are grown under varied agroclimatic conditions (soil types, rainfall and thermal regimes) in West Bengal. Yet, the availability of region-specific production technologies is lacking, including crop varieties with traits relevant to prevailing biotic and abiotic stresses and cropping sequences in the region. Poor native Rhizobium (soil bacteria) has been observed in 40% of West Bengal's pulse growing areas which means that it is less efficient at fixing nitrogen in the soil (Reddy, 2009). Yet seed inoculation with a suitable Rhizobium strain (which could boost lentil productivity by 10-12%) is not widely implemented. Despite an increase in irrigated area, cereals or cash crops are often prioritized, and pulses including lentils are relocated to rainfed areas which make these crops vulnerable to biotic and abiotic stresses. Currently, only 12% of the irrigated area in West Bengal is currently under pulses (Reddy and Reddy, 2010). Other constraints to boosting yields include the use of a low seed rate (10-15 kg/ha) and improper sowing methods (often broadcasting in a standing crop), no land preparation, no application of chemical fertilizer, insecticides and pesticides, and no irrigation.
- **Credit and market constraints**: Marginal farmers are most likely to be engaged in lentil cultivation, and, with limited

resources, struggle to access credit to invest in their crops. Markets are also fragmented and infrastructure for storage and post-harvest processing near production areas is lacking. Consequently, most farmers sell their produce at a very low price to local village traders.

- **Varietal constraints**: A lack of access to high-yielding, short-duration varieties means that most farmers plant traditional varieties. These traditional varieties have a low harvest index (the ratio of grain to total dry matter; used as a measure of productivity), are susceptible to pests and diseases, have intermediate growth habits, do not respond well to inputs, and have unstable performances.
- **Unavailability of suitable information**: There is a lack of informative and timely brochures, pamphlets, leaflets, and news about new varieties and better inputs, and the benefits of using modern varieties for farmers in West Bengal. Farmers are often illiterate, and with little access to information are therefore unaware about new varieties and modern technologies that could be used to boost their lentil production.
- **Risk adverse**: Small farmers are less able to take a risk on adopting improved technologies, and the risks involved in growing lentils are not compensated under the Minimum Support Price (designed to ensure that harvest prices for other crops are higher than the production costs).

3. Achievements

Under the ICARDA project, which provided farmers with 29 new high-yielding lentil cultivators and an improved package of agronomic practices, lentil productivity rose by 36.61% compared to traditional growers. The technological change (use of new varieties and practices) contributed 31.81%, while substitution with higher-quality inputs amounted for the other 4.81%. Proper land preparation, use of quality seed, and better pest and disease management were the prime factors behind the enhancement of lentil productivity.

After surveying 135 farm households (with 90% belonging to low and poor economic status groups), it was observed that years of farming experience and level of basic education were the prime factors in determining how likely a farmer was to adopt new technology and seeds. Of these farmers who adopted a new variety, most began to cultivate Moitreyee, followed by Bari-7, PL-6 and HULL-57 (with the 29 new certified seeds having a germination percentage of between 71-80%).

On average, farmers applied 31 kg/ha of the new lentil seeds when planting (priced at Rs. 53/kg), and operational costs for the year totalled Rs. 24,731/ha (approx. US$300). Average production on 0.19 ha of land (with medium fertility status) was 181 kg, where 40 kg was consumed and 141 kg was sold on the local market. An average transportation cost to sell seeds was Rs. 163, with middlemen taking a share of Rs. 249 on an average for every sale. Each farming household consists of five members, on average, and has an average annual expenditure of Rs. 57,868, and a daily intake per household of 71g of pulses per day. Overall, we found that the cost benefit ratio for lentil was 1.25 for farmers who adopted ICARDA's technologies, compared to 0.74 for traditional cultivators which meant that it cost them more to grow than they earned.

4. Policy recommendations

- **Continue to develop input-responsive, non-lodging and very short duration lentil varieties** to mitigate problems like germination loss and yield loss due to environmental factors, such as untimely rains, cyclones etc., which specifically occur during the harvesting season, causing huge production losses. Development of early matured varieties of lentil (L-4717: maturity in 105-107 days) is highly recommended; a shorter vegetative phase and early flowering also results in higher yields. L-4717 has been widely adopted in various parts of West Bengal, particularly for seed production in Hooghly Goghat-I block, but the block in general is mono-cropped and dependent on the winter rabi season. So, research needs to be particularly targeted at different blocks to raise the livelihoods of pulse farmers.
- **Improve marketing infrastructure and marketing channels for marketing of pulses**. Our study completed region-specific market surveys to determine market margins (the difference between producer and consumer price), to highlight how this varies. Our data revealed that the market margins for lentil range from as high as Rs. 65-75/kg in 24-Parganas, to as low as Rs. 30-55/kg in Haringhata market. The higher margins in some markets are likely to be caused by middlemen hiking prices, which reveals why region-wide information about pulse marketing should be made more widely available for farmers. Providing farmer cooperatives with dehuller machines will also help farmers to process lentil and sell the processed products, which will increase farmers' percentage of the money consumers spend on lentils by around 40%. This will enhance farmer incomes and boost interest from other farmers in lentil production.
- **Bring additional areas under pulse production**. The scope for introducing pulse crops in rice-fallows (mostly un-irrigated) needs to be exploited with supplemental irrigation. There is a vast area of fallow land in West Bengal (1.7 million ha), with most suitable for pulse cultivation. A national taskforce on pulses, created in 2015, has already identified the areas with the greatest potential for expansion (Reddy, 2015). The recommendations from the pulse taskforce include:
  - Utilize rice fallow land (3-4 million ha) in eastern India. This would yield around 2.5 million tons of pulse each year.

ICARDA's input-responsive, non-lodging and short duration lentil varieties have proven to be successful in West Bengal.

In rice-fallow areas, ICARDA varieties are recommended for paira cropping with paddy: B-77 (Asha), B-56, K-75 (Mallika), WBL 58 (Subrata), Pant L 6, Pant L 406, Pant L 639, Subhendu (WBL 81), B-256 (Ranjan), NDL-1, WBL-77 (Moitrayee), KLS-2018, Hul-57, L-4717 (short duration).

Hull-57 was adopted by 171 households in Hooghly (Balagarh, Kota, Goghat-I and II), Murshidabad (Bhagabangola), Nadia (Harekrishnapur) and Bankura (Gangajalghati, Khatra, Indpur, Chhatna, Jhilmili) districts. The mean yield was 1,350 kg/ha and the benefit cost ratio was 2.2.

PL-406 was adopted by 89 households in Nadia (Chapra Dhantola, Bizra, Kurumbelia, Dakalipara) District. The mean yield was 780 kg/ha, and the benefit cost ratio was 1.49.

L-4717 (early) was adopted by 24 households in 24-Parganas North District. The mean yield was 2,150 kg/ha, with a benefit cost ratio of 2.86.

Barimusur-7 was adopted by 56 households in the North Bengal districts of Malda (Gajol, Chanchol) and Dinajpur South (Balurghat). The mean yield was 850 kg/ha, with a benefit cost ratio of 1.51.

- Diversify 500,000 ha of low-yielding upland rice, 450,000 ha of millet and 300,000 ha of barley, mustard and wheat, by bringing these areas under *rabi* pulses.
- About 1.65 million ha vacated by wheat, pea, potato and sugarcane production can be used to grow 60-65 day summer mungbean crops in states (including West Bengal) where adequate irrigation facilities exist (Singh, Shahi and Singh, 2017).

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