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Enhancing castor crop yield and farmer income through high-yielding variety GCH 7: A case study of cluster front line demonstrations in Kutch region

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Abstract
Castor is one of the most important cash crops, which plays a major role in increasing the income of the Kutch region's small and marginal farmers. To promote the improved cultivation technology of castor with high-yielding variety GCH 7, ICAR-CAZRI, Krishi Vigyan Kendra Kukma Bhuj-Kutch (Gujarat) conducted 150 cluster front line demonstrations (CFLDs) with an acreage of 60 hectares during *kharif*, 2017-18 to 2020-21. The four years data stated that the average yield increased (16.34%) from 2368 kg (existing practice) to 2754 kg recorded under improved approach. The average technology gap, extension gap and technology index were 385.5kg/ha, 446.5kg/ha and 13.96%, respectively. Furthermore, the economics of the demonstration and farmers' practice showed an increased net return of Rs. 76,005 ha^{-1} with benefit-cost ratio (BCR) of 2.72 in demonstrated plots over conventional plots where it was Rs.62, 245 ha^{-1} and 2.52. By conducting frontline demonstrations of proven technologies, the yield potential of castor crops could be greatly enhanced with the increase in the income level of the farming community.

Keywords: Castor, adoption, impact, CFLD, gross return, extension gap, technology index

Introduction
Castor, *Ricinus communis*, is a perennial oilseed crop that belongs to the *Euphorbiaceae* spurge family. It is largely utilized in producing soaps, lubricants, hydraulic and brake fluids, paints, dyes, coatings, inks, cold-resistant plastics, waxes and polishes, nylon, pharmaceuticals, and perfumes, among other things. Castor oil is expected to play a considerably greater role in the global economy as worries about biofuels, particularly biodiesel and biopolymer, grow worldwide. Nutritional unsaturated acids have recently been discovered to have a crucial role in decreasing individual risks connected with illnesses, including asthma, cardiovascular disease, cancer, and diabetes, according to a new study (Anonymous, 2020) [1]. Although *Ricinus communis* is native to the southern Mediterranean Basin, Eastern Africa, and India, it is now in tropical areas worldwide (Phillips and Rix, 1999) [7]. It is seeded in July/August in India, and harvesting begins in January/February. Temperatures between 20 and 25 °C are good for castor growth; however, temperatures below 12 °C or beyond 38 °C impact germination and production. India is the world's greatest producer of castor seeds and the world's largest exporter of castor oil, accounting for 92 percent of global output, followed by China and Brazil.

In India, the castor area was estimated to be 9.38 lakh hectares, up from 8.76 lakh ha the previous year. Gujarat (7.02 lakh ha), Rajasthan (1.54 lakh ha), Andhra Pradesh (0.33 lakh ha), Telangana (0.22 lakh ha), and Odisha (0.04 lakh ha) are the biggest castor-producing states (Anonymous, 2019-20) [2]. Gujarat, the country's biggest producer, is expected to produce 1.744 million tonnes of castor in 2019-20, accounting for 96% of total castor output. Most farmers are growing this crop as an irrigated crop, using hybrid types. In Gujarat, the Kachchh district has 1,33,589 acres under this crop, accounting for 18.14 percent of the state's total castor-producing area (Anonymous, 2019-20) [2]. Farmers were found to be dealing with a variety of issues in castor production, including a high incidence of insect pests (whitefly, semilooper, capsule borer) and diseases (seedling blight, Fusarium wilt, and leaf spot), soil salinity, poor quality irrigation water, a lack of high-quality seed, adverse effect of climate variability like female to male flower conversion, and so on. Farmers were also employing ancient castor varieties without properly using high-yielding variety seeds or an updated package of practices. With these limits in mind, KVK Bhuj performed CFLDs on this significant cash crop, ensuring the livelihood and economic empowerment of castor farmers in the area.

Materials and Methods

ICAR-CAZRI, Krishi Vigyan Kendra, Kukma, Bhuj conducted the research in Gujarat's Kachchh area. Bhuj and Anjar blocks were chosen randomly from ten blocks for cluster frontline demonstrations (CFLDs). During *kharif*, 2017-18 to 2020-21, as part of the National Food Security Mission on oilseeds, 150 cluster frontline demonstrations were held in a 60 ha area at different locations, as shown in Table-1.

Table 1: Year wise number and area of CFLDs covered in different villages

S. No.	Year	No. of Demonstrations (No.)	Area (ha)	Adopted villages for intervention
1.	2017-18	75	30	Varli, Trambau, Kotda Chakar, Modsar and Rapar Khokhara
2.	2018-19	25	10	Rampar, Chapredi, Atal Nagar and Modsar
3.	2019-20	25	10	Ambapar and Modsar
4.	2020-21	25	10	Mokhana, Dhaneti, Modsar, Lakhond, Kukma and Ajapar
Total		150	60	

Before conducting CFLDs, we gathered fundamental data on crop production techniques, soil characteristics, acceptable high-yielding varieties, and the occurrence of insect pests through field surveys and farmer meetings to determine the current condition in greater castor production and, as a result, necessary improvements in cultivation practices were implemented. Improved castor farming technology, including a high-yielding variety of castor (GCH-7) and a whole package of operations, was hosted in various locations over a 60-hectare acreage. The materials or procedures utilized in cluster frontline demonstrations (CFLDs) and farmers' practices are listed in Table 2. The research area's soils were mostly salty and alkaline with pH and EC values ranging from 8.5 to 9.2 and 0.9 to 4.5 dSm-1, respectively, and a sandy-to-sandy loam texture with low nitrogen, phosphorus, essential micronutrients, and organic carbon.

Table 2: Details of material and procedures used under improved practice and local check

S. No.	Operation	Demonstrated improved technology	Farmer's practice
1.	Variety	GCH 7	GCH 2 & 4
2.	Seed treatment	Bavistin @ 2g/kg and Thiamethoxam @ 7g/kg seed before one-day sowing	Generally, not practiced
3.	Date of Sowing	2^{nd} week of August	15^{th} of July
4.	Method of sowing and spacing	Line sowing, 150 x 120 cm	Broadcasting
5.	Fertilizer N-P-K-S and Application time	10 tonnes FYM, N-120 kg+25kg P^2O^5+S-20kg/ha	5 tonnes N-200kg+P-100kg
6.	No. of Irrigation	9-10	14-16
7.	Weed management	Fluchloralin or Pendimathalin of 0.9kg a.i. at pre-emergence stage	Hand weeding at 30-40 days after sowing
8.	Plant protection	Seed treatment with Thiamethoxam 30 FS @ 7g/kg seed and Bavistin @2g/kg seed With the appearance of semilooper and whitefly foliar spray with Chloropyriphos + cypermethrin @ 1.5 ml/liter and thiamethoxam 7g/liter water at 15 days interval	Seed treatment not practiced Spraying with Dimethoate @ 0.05% or monocrotophos 36 SL @ 1-2ml/liter water

The planting took place every year between mid-August and the first fortnight of May under rainfed/irrigated conditions, while the harvest took place between the second and first fortnights of February. The spike may be picked and dried for threshing when the capsules become pale yellow, and a few capsules dry out. As shown in Table 2, farmers got important inputs such as seed, fertilizer, and plant protection chemicals. Farmers chosen for CFLDs were instructed and provided detailed information on properly cultivating castor using the recommended technique package. Farmers, on the other hand, were permitted to carry out their practices in the event of a farmer's practice or a local check. Field days and farmer meetings were conducted so other farmers could learn about the benefits of the varieties and technologies on display. For the comparison study, data on several parameters such as seed yield, percent insect-pest, and disease incidence were gathered separately from improved practice (IP) and farmer's practise (FP). Furthermore, data is tabulated and analyzed by using statistical tools like frequency and percentage. The extension gap, technology gap and technology index were worked out as per formulas given by the Samui *et al.* (2000) [11].

$$\text{Per cent increase in yield} = \frac{\text{Yield gain in IP plot (kg/ha)} - \text{Yield gain in FP plot (kg/ha)} \times 100}{\text{Yield gain in FP plot (kg/ha)}}$$

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - yield under existing practice

Technology index (%) = [(Potential yield - Demonstration yield)/Potential yield] x 100

B:C ratio = Gross income /cost of cultivation (Rs./ha)

$$\text{Impact on yield (\% change)} = \frac{\text{Yield of Demonstration plot} - \text{Yield of farmers practice} \times 100}{\text{Yield of farmers' practice}}$$

$$\text{Impact on adoption (\% change)} = \frac{\text{No. of adopters after FLD} - \text{No. of adopters before FLD} \times 100}{\text{No. of adopters before FLD}}$$

Results and Discussion

Impact on crop yield

The yield of castor was much greater in the demonstration field than in the current practice in both (Bhuj and Anjar) talukas throughout *Kharif*, 2017 to 2021, according to the data presented in Table 3. Data analysis showed that better technical intervention led to a 16.34% greater castor seed production of 2754kg/ha compared to 2368kg/ha recorded with existing techniques (farmers' practice), as shown in Table 3. Naveen *et al.* (2017) [5], Singh *et al.* (2019a) [13], and Tetarwal and Singh (2021) [16] all found similar results.

Table 3: Seed yield, extension gap, technology gap, technology index of castor as under improved and farmer's practices

Year	Yield (kg/ha)			% Increase in yield	Technology Gap (kg/ha)	Extension Gap (kg/ha)	Technology Index (%)
	Potential	Demo	Local Check				
2017-18	3200	2763	2410	14.61	437	353	13.66
2018-19	3200	2657	2292	15.92	543	365	16.97
2019-20	3200	2816	2474	13.82	384	342	12.00
2020-21	3200	2778	2296	20.99	422	482	13.19
Average	3200	2754	2368	16.34	446.5	385.5	13.96

The percent increase in yield of demonstration plots over farmers' plots ranged from 87 to 127 percent. This increase in grain yield of demonstration plots was mainly due to the recommended package and practices followed under the supervision of KVK scientists. Use of GCH 7 improved and recommended variety of castor, optimum sowing time, proper seed treatment, line sowing, recommended dose of fertilizers, integrated weed and plant protection measures followed under CFLDs jumped the yield of castor compared to farmers' practices.

Gap analysis

The technological gap measures the difference between the demonstrated yield and the potential yield, and it was greatest (543 kg/ha) in 2018-19, followed by 2017-18 (437 kg/ha), 2019-20 (384kg/ha) and 422kg/ha in 2020-21. Under the four-year CFLD initiative, the average technology gap was 446.5kg/ha, as shown in Table 3. It indicates that there is still a gap in technology demonstration as a result of which the adopting farmers could not follow up on the potential yield of improved practices. The observed technological gap might be attributable to differences in soil fertility, poor quality irrigation water, insect pest assault, and variable meteorological conditions experienced throughout crop season at different places. Similar findings were observed by Vijaya Lakshmi *et al.* (2017) [17], Zimik *et al.* (2020) [18], and Singh *et al.* (2019b) [14].

The extension gap is a metric to determine the yield difference between a demonstration plot and a plot already in use (existing practice). During the *Kharif*, 2017-18 to 2020-21, a 342 kg ha-1 to 482 kg/ha gap was recorded (Table 3). In the demonstration plot, the average extension gap was 385.5 kg/ha, which must be minimized via various extension activities such as the adoption of high-yielding varieties, training programmes, Kisan Gosthies, and better agro technologies to reverse this trend of broad extension gap. These programmes have the potential to assist farmers in adopting new and improved castor production technologies, resulting in a reduction in the extension gap. The findings of Kaur *et al.* (2020) [3]; Padmaiah *et al.* (2012) [6] and Romade *et al.* (2018) [9] supported the present investigations.

The technology index was defined as the percentage ratio of the technological gap to potential yield. The technology index demonstrates the viability of advanced technologies in farmers' fields. According to the statistics (Table 3), the highest technology index value of 16.97% was recorded in *Kharif* 2018-19, while the lowest technology index value of 12.00% was recorded in *Kharif* 2019-20. During four consecutive years of CFLDs on the oilseed programme, the average technology index in castor crops was 13.96%. Singh *et al.* (2019a) [13], Ranjita and Deka (2020) [8], and Singh *et al.* (2020) [15] found similar results.

Economics performance

The data presented in Table-4 shows the cost of cultivation, gross return, net return, and benefit-cost ratio (BCR) of castor crop in improved practise under cluster frontline demonstration and existing farmers' practise. The average cost of cultivation rose in enhanced practice (Rs. 44,250 ha^{-1}) compared to conventional methods (Rs. 41,075 ha^{-1}). The demonstration plot (Rs.1,20,255ha^{-1}) produced considerably greater average gross returns than farmers' practices (Rs.1,03,320 ha^{-1}). Compared to the farmer's practice (2.52), the average BC ratio of the demonstration plot (2.72) was greater. Ranjita and Deka (2020) [8]; and Padmaiah *et al.* (2012) [6] have also found similar findings.

Table 4: Economic performance of castor crop under cluster front line demonstrations at farmer's field

Year	Economics of demonstration plot (Rs./ha)				Economics of conventional plot (Rs./ha)			
	Gross Cost	Gross Return	Net Return	BCR (R/C)	Gross Cost	Gross Return	Net Return	BCR (R/C)
2017-18	44000	110520	66520	2.51	40000	96400	56400	2.41
2018-19	44000	132850	88850	3.02	40000	114600	74600	2.87
2019-20	44500	112640	68140	2.53	41000	98960	57960	2.41
2020-21	44500	125010	80510	2.81	43300	103320	60020	2.39
Average	44250	120255	76005	2.72	41075	103320	62245	2.52

Impact on Adoption

According to the data presented in Table 5, the number of adoptions for field preparation and usage of FYM for castor crops was 65.3 percent before field demonstrations and jumped to 85.3 percent after frontline demonstrations in adopted villages. A similar trend was seen in the adoption of high-yielding varieties, as well as sowing time and spacing, with the percentage of adopters rising from 29.3 to 83.3 and 50 to 94.7 percent, respectively. The number of adopters for fertilizer application and weed control increased from 32 to 82.7 percent and 30 to 60 percent, respectively, over the pre- and post-demonstration periods. The CFLD intervention practices significantly positively impacted the adoption of improved practices. Present investigations conform with the findings of Morwal *et al.* (2018) [4].

Table 5: Impact of frontline demonstrations on adoption of improved practices on yield castor crop

S. No.	Improved practices followed	Number of Adoptions (N=150)		Change in no. of adopters	Impact (% change)
		Before intervention	After intervention		
1.	Field preparation & use of FYM	98 (65.3)	128 (85.3)	+30	+30.61
2.	High yielding variety (GCH-7)	44 (29.3)	125 (83.3)	+81	+184.09
3.	Time of Sowing and spacing	75 (50)	142 (94.7)	+67	+89.33
4.	Fertilizer application NPKS & Gypsum	48 (32)	124 (82.7)	+76	+158.33
5.	Weed management	45 (30)	90 (60)	+45	+100
6.	IDM and IPM practices	42 (28)	120 (80)	+78	+185.71

Conclusions

Frontline demonstrations on castor in a cluster approach effectively persuade not just the participating farmers but also the farms next door. To close these gaps, joint extension initiatives are needed to increase farmers' adoption of location and crop-specific technology. The significant benefit-cost ratio explained the demonstration's economic feasibility, which persuaded the farmers to implement the intervention. Horizontal distribution of better technologies may be achieved by the successful execution of frontline demonstrations and different extension activities such as training, field days, and exposure visits arranged through CFLDs programmes in farmers' fields. Farmers strongly desire to plant these types in large quantities in the next seasons.

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