POLICY BRIEF 56

Economic Impact of Salt-Tolerant Mustard Varieties

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Soil salinity is one of the most prominent forms of land degradation in India. Around 6.74 million hectares of land, equivalent to 5% of the net sown area, suffers from salinity. In the absence of the preventive or ameliorative measures, it is projected to increase to 16.2 million hectares by 2050.[1] Salinity renders land less suitable for crops' cultivation, reduces their production potential, and increases cost of cultivation, which ultimately affect the farm profits. In 2014-2016, crop output worth Rs 230 million or 1.4% of its value was lost due to sodicity and salinity.[2]

Nevertheless, there are several technological and agronomic options to reclaim the salt-affected soils. These include application of gypsum and chemical and biological amendments, plantation of suitable tree species, and cultivation of salt-tolerant crops or crop varieties.

Mustard is one of the preferred crops for cultivation in the salt-affected soils. Given the higher cost of reclamation of the salt-affected soils, breeding for salt-tolerance is a cheaper and sustainable option to effectively utilize the salt-affected agricultural lands. ICAR-Central Soil Salinity Research Institute has over time developed salt-tolerant varieties of mustard such as CS52, CS54, CS56, CS58 and CS60. These can tolerate sodicity up to pH 9.4 and salinity up to 12 dS/m. In normal soils their yield is 2.0 to 2.9 t/ha and it ranges between 1.6 to 2.2 t/ha in salt-affected soils (Table 1). In this brief, we have assessed the adoption and impact of four salt-tolerant mustard varieties (STMVs), namely, CS54, CS56, CS58, and CS60. CS52, the earliest salt-tolerant variety, is not included due to lack of sufficient information required for estimating area under its cultivation.

Economic impact of these varieties has been assessed for 2004-2022, and further projected to 2030. Data on seed requirement and distribution were obtained from the annual reports of ICAR-CSSRI.

Target Domain for Salt-Tolerant Mustard Varieties

In India, mustard is one of the most important edible oil crops, in both production and consumption. It is cultivated in 6.70 million hectares, equivalent to 3.2% of the total cropped area. It is a prominent *rabi* (winter) season crop, occupying 10.57% of the total *rabi*-cropped area (63.38 million ha). Overall, mustard shares 23.24% of the total area under oilseeds.

Mustard is widely grown in Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Gujarat, and West Bengal. These states together occupy 5.65 million hectares, i.e., 84% of the total mustard area (Figure 1). In these states, 4.93 million hectares of cultivated land is estimated to be affected by salinity and sodicity.[3] The general trend in the yield of mustard is presented in Figure 2.

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[1] CSSRI (2015). *Vision 2050.* ICAR-CSSRI, Karnal, Haryana, India.

[2] Sharma, D.K., Thimmappa, K., Chinchmalatpure, A. R., Mandal, A.K., Yadav, R.K., Chaudhury, S.K., Kumar, S. and Sikka, A. (2015). *Assessment of Production and Monetary Losses from Salt-affected Soils in India.* Technical Bulletin, 05/2015, ICAR-CSSRI, Karnal, Haryana, India.

[3] Mandal, A. K., Sharma, R. C., Singh, G. and Dagar, J. C. (2010). *Computerized Database on Salt-affected Soils in India*, Technical Bulletin, 02/2010, ICAR-CSSRI, Karnal, Haryana, India.

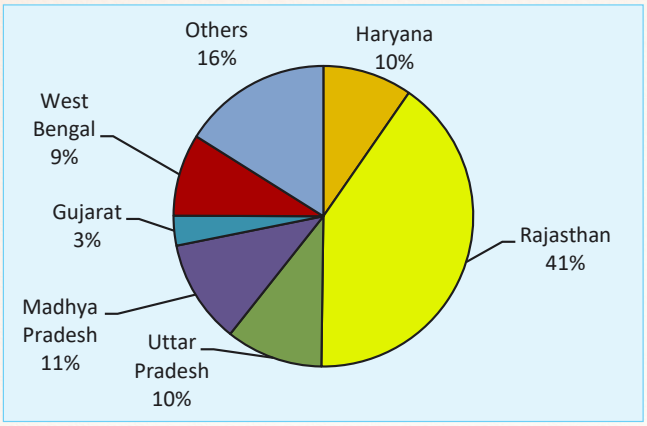

Figure 1. Distribution of area under mustard across the states in India, 2020-21

Table 1. Salt-tolerant mustard varieties

Variety	CS54	CS56	CS58	CS60
Year of release	2005	2008	2017	2018
Plant height (cm)	160-170	198-202	180-185	182-187
Maturity (days)	121-125	132-135	130-135	125-132
Seed type	Bold	Medium	Bold	Bold
1000 seed weight (gm)	5.05 - 5.55	4.5 - 5.0	5.0 - 5.5	5.0 - 5.2
Salinity tolerance (dS/m)	6 - 9	6 - 9	6 - 11	6 - 12
Sodicity tolerance (pH)	8.5-9.3	8.5-9.3	8.5-9.4	8.5-9.5
Normal yield (t/ha)	2.0 - 2.4	2.2 - 2.6	2.6 - 2.8	2.5 - 2.9
Yield in salt-stressed soil (t/ha)	1.6 - 1.9	1.6 – 1.9	2.0 - 2.2	2.0 - 2.2
Oil content (%)	38 - 39	38 - 39	39 - 40	40 - 41
Time of sowing	15 Oct.	15 Nov.	15 Oct.	25 Oct.

The STMVs have been found to perform better in salt-affected soils as compared to their counterpart non-salt-tolerant varieties. CSSRI receives indents for breeder seed from the Ministry of Agriculture and Farmers Welfare, Government of India, which is multiplied by the state/central seed corporations and private seed companies for supplying to farmers. CSSRI also produces certified seeds for farmers. The area under salt-tolerant varieties has been estimated using information on breeder seed demand from 2005 to 2021.[4] The value of mustard output during 2004 to 2021 has been estimated at Rs 5,677 crores.

Economic Surplus Model

Economic surplus model is used to assess the economic benefits due to the adoption of STMVs. Economic surplus is the total net benefits or gains to both producers and consumers. The adoption of STMVs directly benefits producers by shifting the supply curve upward, and indirectly to consumers by reducing the prices .[5]

Assuming linear demand and supply curves, the change in producer surplus (ΔPS) and consumer surplus (ΔCS) in a closed economy case are computed using equation (1) and equation (2), respectively.

$$\Delta PS = P_0 Q_0 (K - Z)\,(1+0.5\varepsilon_d Z) \ldots\ldots (1)$$

$$\Delta CS = Z P_0 Q_0 (1 + 0.5\varepsilon_d Z) \ldots\ldots \quad (2)$$

Where, P_0 is the price of mustard, Q_0 is the pre-adoption level of production, Z is the relative change/reduction in price, and K is a shift parameter measuring reduction in production cost *i.e.* the extent of downward vertical shift in supply curve. The ε_s and ε_d represent price elasticity of supply and demand, respectively. The value of these parameters have been obtained through surveys or taken from published literature (Table 2).

Economic Benefits of Salt-tolerant Mustard Varieties

The loss in yield due to salt stress in popularly grown mustard varieties or hybrids is compensated by their higher yield and higher market price. For example, hybrid Pioneer 45S46 provides 15% higher yield than CS60 under normal soil without salinity stress. Additionally, hybrid mustard fetches marginally higher market price due to higher oil content. Farmers, therefore, are attracted to grow these hybrids. But the cost of cultivation of STMVs is less by 8% primarily

[4] CSSRI (2005-2021). *Annual Report.* ICAR-CSSRI, Karnal, Haryana, India.

[5] Alston, J. M., Norton, G. W. and Pardey, P. G. (1995). *Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Cornell University Press.

due to the lower seed price as compared to the price of hybrid seed. Many a times, farmers even do not know whether their land is salt-affected. They realize it only when significant yield loss occurs, and farmers then adopt STMVs.

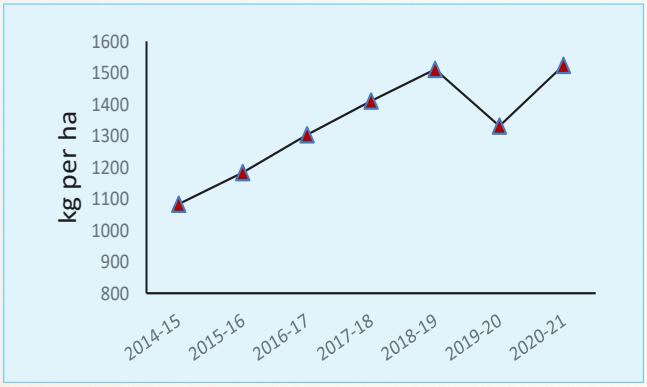

Figure 2. Trend in mustard yield of India

The STMVs also outperform the non-STMVs under multiple stresses, including sodicity (pH > 8.5), low temperature, and aphid infestation. Based on seed demand for STMVs, these are estimated to be cultivated in 5.2% of the total mustard area (Figure 3). By 2030, given the increase in salt-affected area, their adoption rate is also projected to increase to15.2%.

The economic surplus resulting from the adoption of STMVs has been estimated under different scenarios: (i) for 2005-2022 when the adoption rate reached a maximum 5.17% in 2022, (ii) for 2005-2030 under a business as usual increase in adoption rate, reaching to 10.04% in 2030 (scenario I), and (iii) at a maximum adoption rate of 15.18% in 2030 (Scenario II). Scenario II is likely to prevail because of increase in the salt-affected area and other environmental stresses.

Table 2. Parameters used in Economic Surplus model

Parameter	Symbol	Value
Production quantity in domain areas ('000 t, TE 2005-06)[6]	Q_0	6991
Price (Rs/t, TE 2021-22)[7]	P_0	52270
Increase in yield (%)[8]	$E(Y)$	16
Increase in variable cost per ha (%)[12]	$E(C)$	5.0
Maximum adoption rate(%)[9]	A_{max}	15
Supply elasticity[10,11,12]	ε_s	+0.526
Demand elasticity[13,14]	ε_d	- 0.753

Note: Average of supply and demand elasticities have been used based on relevant literatures.

The yield advantage of STMVs was estimated through primary surveys and focused group discussions. In salt-affected soils, their average yield is about 16% more over other varieties. The cost of cultivation is, however, higher by 5.45%. The production in the base year (TE 2005-06), denoted as Q_0, was about 7 million tonnes. It is valued at a mean producer price of Rs 52,270 per tonne prevalent during TE 2021-22.

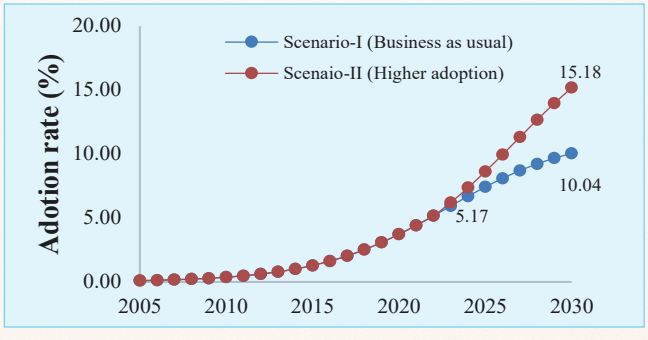

Figure 3. Projected adoption curve of salt-tolerant mustard varieties

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[6] GoI-Government of India (2022). Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, New Delhi: https://eands.dacnet.nic.in.

[7] GoI (2023), *Farm Harvest Prices of Principal Crops in India 2021-22*, Ministry of Agriculture and Farmers Welfare, New Delhi: https://eands.dacnet.nic.in.

[8] Based on focused group discussion and primary survey.

[9] Expert consultation (breeders). Adoption path was traced using logistic curve.

[10] Pandey, L. M. and Kumar, S. (2005). Instability, supply response and insurance in oilseeds production in India. *Agricultural Economics Research Review*, 18 (conf):103-114.

[11] Mohanakumar, S. (2018). Minimum support price and inflation in India. *Economic & Political Weekly*, 53(47), 11.

[12] Kumar, P. and Mittal, S. (2022). *Agricultural Price Policy for Ensuring Food Security in India*, NABARD Research and Policy Series No. 1/2022.

[13] Srinivasan, P. V. (2005). *Impact of Trade Liberalization on India's Oilseed and Edible Oils Sector*. Indira Gandhi Institute of Development Research, Mumbai, Maharashtra.

[14] Sharma, V. V. (1978). Demand and supply relationships for the Indian vegetable oil industry with particular emphasis on estimation and prediction. *The Developing Economies*, 16(3):239-253.

The estimated value of economic surplus was Rs 4,549 crores during 2005-2022, which is projected to increase to Rs 19,432 crores by 2030 at the adoption rate of of 10.4% (Table 3). The benefits will be more if the adoption rate increases to 15.2% (i.e., Rs 24,075 crores). "Notably, producers share about 59% of the surplus due to STMVs."

Table 3: Estimated economic surplus due to salt-tolerant mustard varieties

Economic surplus	Rs crores		
	Scenario I (business as usual)		Scenario II (higher adoption)
	2005-2022	2005-2030	2005-2030
Consumers' surplus	1872	7998	9909
Producers' surplus	2677	11434	14166
Total economic surplus	4549	19432	24075

Policy Implications

Given their tolerance to multiple stresses, the salt-tolerant mustard varieties have considerable potential to reduce income loss due to sodicity and salinity. Yet, the private-sector dominates the seed market due to its aggressive marketing strategies. Most farmers lack awareness of the salt-stress conditions unless their land is severely affected and crop loss is significant.

Salt-tolerant mustard varieties are found to perform exceptionally well under multiple stress conditions, including the high soil pH, very low temperatures, and aphid infestation. Further, in view of the increasing frequency of weather aberrations like erratic rainfall and temperature in plausible climate scenarios, it is imperative to promote varieties that also perform under changing climate.

Importantly, India heavily depends on imports of edible oils to meet its domestic demand. Between 55-60% of the edible oil demand is met through imports. Mustard oil is one of the most preferred edible oils in India. Hence, it is imperative to increase the domestic production of mustard seeds.

Recognize that farmers prefer high-yielding varieties or hybrids irrespective of whether their soils suit their cultivation. Hence, future breeding strategies should incorporate salt-tolerance traits in high-yielding varieties. This shift in breeding strategy from "exclusively salt-tolerance" to "higher-yield plus salt-tolerance" is crucial in meeting the growing demand for edible oils, and also increasing farm profits.

Strengthen the seed supply chains by involving key stakeholders and fostering partnerships between public and private seed producers and distributors.

Create awareness among farmers about the long-term adverse effects of salts on the sustainability of agriculture, as well as the benefits of adopting salt-tolerant crops and their varieties. Significant efforts are needed to promote salt-tolerant crop varieties.

The economic impact of STMVs suggests a greater emphasis on agricultural research for breeding stress-tolerant and high-yielding crops. It's important to note that breeding crops for stress tolerance is not only cost-effective but also a sustainable means of managing salt-affected soils compared to other available options for sodicity and salinity.

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