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The Retrospect and Prospects of Pearl Millet (Bajra) Cultivation in Punjab

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Abstract

Pearl millet (Bajra) has been an integral part of Punjab's agricultural landscape for decades. However, in recent years, there has been a shift towards the intensive rice-wheat system, which has marginalized pearl millet cultivation. With this background, present study aimed to examine the historical context and future potential of pearl millet cultivation in Punjab. This study was based on secondary data. The results showed that the Punjab's area under pearl millet cultivation has shown a declining trend over the years, with a peak at 207 thousand hectares in 1970-71 but gradually decreased to 0.4 thousand hectares in 2020-21. Pearl millet production in Punjab ranged from 59 thousand tonnes in 1959-60 to 0.26 thousand tonnes in 2020-21, with a significant decline in production over the years. It was observed that the total operational cost of cultivating pearl millet in major states ranges from Rs. 29,000 per ha in Uttar Pradesh to Rs. 59,000 per ha in Maharashtra, whereas in case of Punjab it was on the lower side of this range with Rs. 35,500 per ha. However, human labour and machine labour were the major operational cost in all the major producers whereas in Punjab human labour cost and fertilizer & manure costs were major component of operational costs. Human labour cost was highest because harvesting and threshing of pearl millet is still done manually. Gross returns from pearl millet cultivation in Punjab was about Rs. 12,700 per ha which is too low and the reason for this was due to low average yield (i.e., 6.4 qtl/ha). The crop is currently unprofitable compared to paddy due to low yields. This highlights the fact that Punjab requires high yielding varieties. The average price received on pearl millet sale by Punjab farmers was around Rs. 2000/qtl lesser than MSP announced. State government should procure pearl millet at MSP so that area under pearl millet in Punjab could be increased replacing paddy.

Keywords: Pearl millet, Retrospects, Prospects, Cost of cultivation, Exports

JEL codes: Q10, Q13, Q17, Q18

Introduction

The Green Revolution, which catapulted Punjab into the agricultural spotlight, primarily focused on high-yielding varieties of wheat and rice. As a consequence, lot of low value crops like pearl millet, maize, groundnut etc. took a backseat in the cropping pattern, and its cultivation dwindled. However, the contemporary agricultural scenario is witnessing a paradigm shift, with a growing awareness of the need for crop diversification and sustainable practices., Pearl millet also known as Bajra, has been an integral part of Punjab's agricultural landscape for decades. Pearl millet cultivation in Punjab has a long history and played crucial role in the agricultural landscape of the region (Sangha, 2014; Chaudhri and Dasgupta, 2019). However, in recent years, there has been a shift towards the intensive rice-wheat system, which has marginalized pearl millet cultivation (Dhillon, 1994; Rani *et al*., 2021). This shift has led to a decrease in the area under pearl millet cultivation and a decline in its production in Punjab. One of the major benefits of pearl millet cultivation is its high nutritional value. Pearl millet is rich in proteins, carbohydrates, and essential minerals, making it a valuable food crop. Furthermore, pearl millet is known for its tolerance to drought and poor soil fertility, making it suitable for cultivation in arid and semi-arid regions (Jukanti *et al.,* 2016; Khajuria *et al.,* 2022).

In recent years, Punjab's agriculture has been grappling with challenges such as depleting water tables, soil degradation, and a rising incidence of crop residue burning. In this context, the retrospects of pearl millet cultivation gain significance. Pearl millet, with its minimal water requirements and ability to thrive in less fertile soils, emerges as a resilient option for farmers facing the brunt of ecological imbalances (Ezzati et al 2002). The increasing consumer awareness of the nutritional benefits of millets, including pearl millet, has also contributed to a renewed interest in their cultivation. Pearl millet is rich in essential nutrients, gluten-free, and possesses

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a low glycemic index, making it a healthy alternative in an era where dietary preferences are shifting towards wholesome, nutritious options (Rai *et al.,* 2008; Satyavathi, 2021).

The prospects of pearl millet cultivation in Punjab appear promising for several reasons. Therefore, it is crucial to promote and support pearl millet cultivation in Punjab through various means such as providing farmers with training and technical assistance, improving access to credit and agricultural inputs, and raising awareness about the nutritional benefits of pearl millet. With this background, present study aims to explore the retrospects and prospects of pearl millet cultivation in Punjab.

Data Sources and Methodology

This study is based on secondary data. Information related to the area, production and productivity of pearl millet from 1960 to 2021 was gathered from different published sources like Agricultural Statistics at a Glance, Statistical Abstract of Punjab etc. The cost of cultivation data were collected from the Directorate of Economics and Statistics, GOI and for Punjab data were collected from Punjab Agricultural University (PAU) enterprise budgets. Average modal prices of pearl millet were collected from AGMARKNET website. The analysis was done using average, percentage, budgeting techniques and compound annual growth rate (CAGR) to analyse outcomes as per objectives of the study. Data on exports and export potential of pearl millet (HS 100829) was collected from the ITC trade map website for the period 2013 to 2022. Export potential and competitors in major export destinations of India were analysed.

In order to examine the feasibility of pearl millet being a potential alternative for crop diversification for Punjab's farmers, we simulated a scenario to check how pearl millet could be more profitable than paddy. For this purpose we have used breakeven point and feasibility analysis. This method is in line with a variation of the same as that used by James *et al* (2010) and Landers *et al* (2012) with some changes. First of all we calculated the break-even yield for pearl millet to match paddy's profitability, then a 10 per cent increase in yield was done further to surpass paddy's profitability and finally analysed the feasibility of the calculated yield using price data.

Results and Discussion

Since 1970s, both the area under cultivation and the amount of pearl millet produced in Punjab have significantly decreased due to increase in assured irrigation through tubewells. Rice crop replaced the pearl millet cultivation on a large scale in the kharif season. This decrease contrasts with the success of nearby states like Haryana, where pearl millet production has increased dramatically.

Retrospects of pearl millet cultivation

Punjab's area under pearl millet cultivation has shown a declining trend over the years. It peaked at 207 thousand ha in 1970-71 but has gradually decreased to 0.4 thousand ha in 2020-21. This indicates a significant decline (i.e., -64% CAGR) in pearl millet production in Punjab (Table 1). While Gujarat, Rajasthan, and Maharashtra have maintained a relatively stable or increasing area under pearl millet cultivation, Punjab's performance has been on a decline. Possible factors contributing to this decline could include changes in agricultural practices, shift in crop preferences, or other regional factors. Pearl millet production in Punjab ranged from 59 thousand tonnes in 1959-60 to 0.26 thousand tonnes in 2020-21 (Table 1). There has been a significant decline (i.e., -63 % CAGR) in pearl millet production over the years in Punjab. The production peaked in 1970-71 at 243 thousand tonnes, but it gradually decreased thereafter. The current production levels are relatively low compared to earlier years. While Punjab has experienced a decline in pearl millet production, its neighbouring state Haryana has witnessed a remarkable growth in pearl millet production. Haryana's production levels have surpassed Punjab's, with a higher range of production from 236 thousand tonnes to 1350.14 thousand tonnes in 2020-21 (Table 1). This suggests that Haryana has been able to enhance its agricultural practices and achieve notable success in pearl millet cultivation. It's impressive to see how Haryana has achieved significant growth in pearl millet production, contrasting the declining trend observed in Punjab. Pearl millet yield in Punjab ranged from 480 kg/ha in 1960-61 to 640 kg/ha in 2020-21 (Table 1). The yield shows fluctuations over the years, with higher yield in the 1970s and a relatively stable yield in recent years. However, compared to other major producing states pearl millet yield in Punjab is comparatively very low. Hence, there is a need to develop high yielding varieties.

Based on the data in table 1, we can make three groups of states according to their contribution to pearl millet production i.e., high, moderate and low contributors. The states like Rajasthan, Uttar Pradesh, Haryana, and Gujarat are the major contributors with consistent production levels that have contributed almost more than 80 per cent of the total country's production. The states like Madhya Pradesh, Maharashtra, Karnataka, and Tamil Nadu are the moderate contributors to the production and Punjab, Andhra Pradesh, Bihar, Delhi, and Odisha contribute very little to the total country's production. Punjabs' pearl millet production has declined drastically from surplus producing and supplying to other states like Gujarat, Maharashtra and Rajasthan during the early 1970s.

During the late 1960s per capita availability in Punjab was around eight kilograms per annum. FCI started procurement of pearl millet from 1965 onwards and purchases were mainly from Rajasthan, Punjab and Haryana till 1970 and after that other states like Gujarat, Andhra Pradesh and Delhi were added. In 1970-71, there was a shortfall in procurement

Table 1. State-wise area, production and yield of pearl millet from 1960-61 to 2020-21

Area under pearl millet (in '000 hectare)									
State/UTs	**1960-61**	**1970-71**	**1980-81**	**1990-91**	**2000-01**	**2010-11**	**2020-21**	**CAGR**	**se(CAGR)**
Rajasthan	4558	5127	5032	4855	4636.9	5488.7	4348.4	-0.31	0.72
Uttar Pradesh	1090	1121	995	785	881	935	907.0	-3.63	0.85
Gujarat	1435	1782	1380	1152	989.2	873	460.3	-16.86	1.48
Haryana	-	879	881	609	608	661	569.2	-8.31	1.15
Maharashtra	1635	1928	1709	1927	1800	1035	687.5	-12.66	2.11
Madhya Pradesh	175	222	199	173	165.2	162.3	327.0	3.87	2.26
Karnataka	500	510	504	420	442	309	222.0	-11.97	1.21
Tamil Nadu	489	490	319	274	129.3	49.5	67.4	-33.52	1.87
Punjab	124	207	71	11	5	3	0.4	-63.64	1.99
Andhra Pradesh	618	584	516	231	143	48	31.0	-42.01	1.75
Jammu & Kashmir	18	19	15	17	13.3	16.6	13.1	-4.65	0.89
Others	801	2	2	1	6.4	20.3	11.1		
India	**11469**	**12913**	**11657**	**10476**	**9828.9**	**9612.3**	**7652.1**	**-5.03**	**0.64**
Pearl millet production (in '000 tonnes)									
State/UTs	**1960-61**	**1970-71**	**1980-81**	**1990-91**	**2000-01**	**2010-11**	**2020-21**	**CAGR**	**se(CAGR)**
Rajasthan	734	2674	1135	2492	2046.7	4566.6	4561.47	29.05	4.74
Uttar Pradesh	429	882	733	875	1277	1557	2014.45	25.37	1.89
Gujarat	480	1575	1222	1025	822.9	1091.3	1008.89	4.00	3.50
Haryana	236	826	484	526	656	1185	1350.14	25.05	3.99
Maharashtra	489	788	760	1114	1087.3	1123	656.56	7.21	2.74
Madhya Pradesh	115	120	121	152	207	308	737.71	33.06	3.56
Karnataka	129	264	154	206	322	334	275.5	13.25	2.63
Tamil Nadu	302	321	268	296	170.4	77.4	158.89	-17.02	2.49
Punjab	59	243	89	12	5	3	0.26	-63.14	3.13
Andhra Pradesh	292	290	336	168	149	87.1	70.71	-23.43	1.54
Jammu & Kashmir	8	11	9	8	6.2	9.9	6.47	-4.26	1.67
Others	12	33	26	20	9.7	27.6	22.12		
India	**3285**	**8029**	**5343**	**6894**	**6759.2**	**10369.9**	**10863.17**	**16.74**	**2.57**
Pearl millet yield (in Kg/ha)									
State/UTs	**1960-61**	**1970-71**	**1980-81**	**1990-91**	**2000-01**	**2010-11**	**2020-21**	**CAGR**	**se(CAGR)**
Rajasthan	161	521	226	513	441	832	1049	29.45	4.37
Uttar Pradesh	394	787	737	1115	1449	1665	2221	30.08	1.67
Gujarat	334	884	885	889	832	1250	2192	25.12	3.28
Haryana	294	940	549	864	1079	1793	2372	34.17	3.66
Maharashtra	299	408	445	578	604	1085	955	22.78	1.421
Madhya Pradesh	657	541	607	880	1253	1898	2256	28.11	2.29
Karnataka	258	517	305	489	729	1081	1241	28.67	2.87
Tamil Nadu	617	656	840	1081	1318	1564	2357	24.83	0.86
Punjab	480	1173	1254	1091	1000	1000	640	1.14	3.31
Andhra Pradesh	473	497	652	725	1042	1815	2281	32.03	1.83
Jammu and Kashmir	437	578	620	467	466	598	492	0.5	1.31
Others	-	-	-	-	-	-	-	-	-
India	**286**	**622**	**458**	**658**	**688**	**1079**	**1420**	**25.3**	**2.33**

from Punjab due to the bulk of the market arrivals were ergot infected and unfit for human consumption. After that area under pearl millet started to decline as farmers shifted towards paddy cultivation.

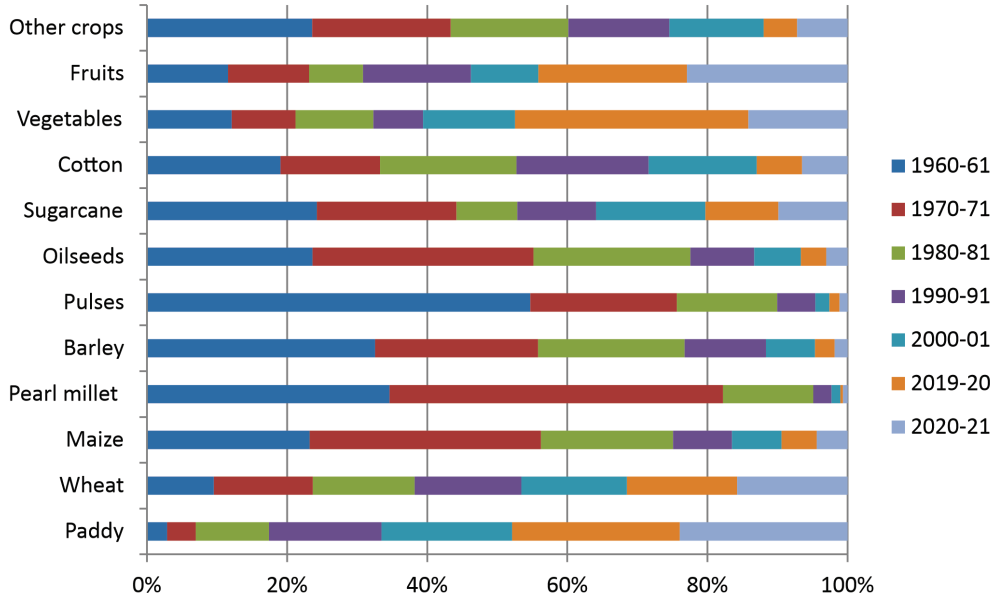
The cropping pattern of the state has changed a lot. The percentage share of pearl millet cultivation has been decreasing over the years, from 2.69 per cent in 1960-61 to 0.05 per cent in 2020-21(Fig. 1). This decline could be attributed to various factors, including changes in demand and market preferences, availability of better alternatives, and shifts in agricultural practices. Pearl millet is traditionally grown as a rain-fed crop in Punjab, and its water requirements are relatively lower compared to paddy. The decline in pearl millet cultivation suggests a shift towards other crops or agricultural practices that may be more economically viable or suitable for the region. Most of the area has been shifted to paddy (Dhillon, 1994; Rani *et al*, 2021). The percentage share of paddy cultivation has been steadily increasing over the years, from 4.80 per cent in 1960-61 to 40.20 per cent in 2020-21. Paddy crop requires assured irrigation facilities and with the increase in area under assured irrigation in the form of tubewells, the farmers have shifted the area from low value crops like pearl millet, maize, groundnut etc. to high value crops like rice in kharif season (Dhindsa and Sharma, 1995). Paddy has become a major crop in Punjab due to favourable climatic conditions and the availability of irrigation facilities. However, the significant increase in paddy cultivation raises concerns about water usage, as paddy is a water-intensive crop. On an average, around 4,000 litres of water is required to grow one kilogram of rice in Punjab. That requires on an average around 54,400 billion litres of water for paddy cultivation in Punjab every year. Paddy emerged as the most water-guzzling crop consuming 45 to 88 per cent higher groundwater than other crops. Since the submission of the Johl committee report in 1986, there has been a suggestion to shift away from the traditional wheat-rice cropping pattern to a wheat-maize pattern in order to address groundwater depletion issues (Sarkar and Das, 2014).

However, altering the cropping pattern has proven to be challenging. Despite many initiatives, the remunerative nature of paddy cultivation, coupled with prevailing conditions such as electricity pricing and minimum support prices, has made paddy the most attractive option for farmers. As a result, farmers may not be inclined to shift towards crop diversification unless economically attractive alternatives are incentivized.

The comparison of cost and returns of Punjab pearl millet growers with major producers of pearl millet in India

States like Gujarat, Haryana, Maharashtra, Rajasthan and Uttar Pradesh are the major producers of pearl millet in the country. To compare the cost and returns from pearl millet cultivation in Punjab with these major producers, we have taken cost of cultivation data of major producing states from https://eands.dacnet.nic.in/ for the year 2021-22 and for Punjab data by consulting agronomist and plant breeders of PAU, we estimated the total operational cost and for calculation of returns, we have taken average yield of Punjab (i.e., TE 2020-21) and average prices of three years (i.e., TE 2020-21).

From the results obtained, it is observed that the total



Source: Directorate of Agriculture and Farmers' Welfare, Punjab

Figure 1. Crop-wise percentage share of cropped area in Punjab (in per cent)

operational cost of cultivating pearl millet in major states ranges from Rs. 29,000 per ha in Uttar Pradesh to Rs. 59,000 per ha in Maharashtra, whereas in case of Punjab it is on the lower side of this range with Rs. 35,500 per ha (Table 2). Human labour and machine labour were the major operational cost in all the major producers whereas in Punjab human labour cost and fertilizer & manure costs were major component of operational costs. Human labour cost was highest because harvesting & threshing of pearl millet is still done manually.

The gross returns from pearl millet sale, range from Rs. 31,000 per ha in Rajasthan with average yield of 10 quintal per ha to Rs. 82,000 in Gujarat with an average yield of 27 quintal per ha. Gross returns from pearl millet cultivation in Punjab was about Rs. 12,700 per ha. Which is too low and the reason for this was due to low average yield (i.e., 6.4 qtl/ha). This highlights the fact that Punjab requires high yielding varieties. The average price received on pearl millet sale by Punjab farmers was around Rs. 2000/qtl which was lesser than MSP announced. State government should procure pearl millet at MSP so that area under pearl millet in Punjab could be increased replacing paddy (Table 2).

Comparison of cost and returns of various kharif crops in Punjab

In order to observe why there is less area under pearl millet crop in Punjab, we have compared cost and returns of different crops grown in the region during kharif season. It is observed that pearl millet cultivation involves less cost compared to all other kharif crops in Punjab but it generates significantly lower gross returns because of lower yield compared to other crops. Pearl millet cultivation in Punjab incurs a substantial loss, with negative net returns over operational costs, making it an unprofitable choice compared to other crops. Paddy is the major crop cultivated in Punjab but it has more operational cost compared to pearl millet however it has assured returns because of procurement by Govt. agencies. Therefore, in order to increase area under pearl millet at least in traditional growing areas of pearl millet, farmers need to be supported by Govt.

In terms of operational costs, pearl millet stands out as the most cost-effective crop among the available crop options to the farmers. The total operational cost for pearl millet cultivation is Rs. 35,511 per hectare, which is relatively lower compared to other crops like paddy (Rs. 48,255), maize (Rs. 57,955), and cotton (Rs. 57,768). This suggests that pearl millet requires fewer resources and inputs to cultivate (Table 3).

Pearl millet has a relatively low yield of 6.4 qtl per ha compared to other crops like paddy (69.8 qtl) and maize (37.5 qtl). However, it is important to note that pearl millet's gross returns are Rs. 12,700 per ha, which is still significant considering its lower operational costs. The net returns over

Table 2. Cost of cultivation of pearl millet in major producing states and Punjab **(Rs./ha)**

	Particulars	Gujarat	Haryana	Maharashtra	Rajasthan	Uttar Pradesh	Punjab
I	**Operational cost**	51552.6	30605.8	58926.2	31617.7	29007.8	35511.2
	Human labour	27959.1	16163.4	30848.2	20409.0	18035.2	24700.0
	Animal labour	728.0	3.6	1724.1	9.4	20.0	
	Machine labour	9543.8	8890.3	17059.6	7479.2	6986.4	2840.5
	Seed	2613.1	996.4	1312.8	1198.9	1640.5	240.8
	Fertilizer & manure	4572.1	2436.1	4323.6	1084.5	955.8	6175.0
	Insecticides	176.8	177.1	34.6	62.4	53.6	210.0
	Irrigation charges	4623.2	1309.8	2277.8	863.1	718.0	479.2
	Miscellaneous	186.3	20.5	48.1	27.8	21.2	424.8
	Interest on working capital	1150.3	608.7	1297.2	483.3	577.1	437.2
II	**Fixed cost**	16743.9	12945.0	14000.3	7926.4	14678.6	
III	Total cost of cultivation	68296.5	43550.8	72926.5	39544.1	43686.4	
IV	Yield (Qtl/ha)	27.7	14.3	26.3	10.9	18.9	6.4
V	**Gross returns (Rs/ha)**	82348.2	39912.5	59958.6	31852.5	39955.5	12700
VI	**Net returns over operational cost**	30795.6	9306.7	1032.5	234.8	10947.6	-22811.2
VII	Net returns (Rs/ha)	14051.7	-3638.3	-12967.9	-7691.6	-3730.9	
VIII	B:C ratio (over operational cost)	1.6	1.3	1.0	1.0	1.4	0.5

Table 3. Cost and returns of different kharif crops of Punjab (Rs./ ha)

		Paddy	Maize	Cotton	Moong	Basmati	Ground-nut	Pearl millet
I	Operational cost							
	Human labour	16811.0	22837.2	26203.7	3408.0	25008	21612.5	24700.0
	Animal labour	4.9	93.7	16.9	0.0	0.0	0.0	
	Machine labour	11461.7	14899.5	11383.9	10165.2	9596.0	7101.3	2840.5
	Seed	1754.9	7995.8	5487.4	4980.6	1585.7	19878.6	240.8
	Fertilizer and manure	4450.6	7288.8	5490.6	411.0	2193.4	12653.8	6175.0
	Insecticides	5841.4	2200.2	6753.5	8740.0	3606.2	1580.8	210.0
	Irrigation charges	6479.0	1096.3	636.4	431.2	8622.8	718.8	479.2
	Miscellaneous	166.5	146.7	287.8	142.6	696.5	13995.0	424.8
	Interest on working capital	1285.3	1397.0	1507.9	802.9	642.2	968.2	437.2
	Total operational cost	48255.1	57955.2	57768.0	29081.4	51951	78509.0	35511.2
II	Fixed cost	53089.3	20117.1	48653.2	33973.7			
III	Total cost of cultivation	101344.4	78072.3	106421.2	63055.1			
IV	Yield (Qtl/ha)	69.8	37.5	22.1	17.1	39.5	29.6	6.4
V	Gross returns (Rs./ha)	142119.5	66205.4	172643.3	105283.7	150176	173394.0	12700
VI	Net returns over operational cost	93864.4	8250.1	114875.3	76202.3	98225	94885.1	-22811.2
VII	Net returns (Rs./ha)	40775.1	-11867.0	66222.1	42228.6			
VIII	B:C ratio (Over operational cost)	2.9	1.1	3.0	3.6	2.9	2.2	0.5

operational costs, pearl millet shows a negative value of Rs. 22,811 per ha, indicating that the operational costs exceed the returns (Table 3). However, this does not necessarily mean that pearl millet is not a viable crop. It's important to consider other factors such as market demand and potential price fluctuations that may affect the profitability.

The wholesale price of pearl millet in major markets of Punjab, Karnataka, Gujarat and Maharashtra during 2002 and 2020 was in the range of Rs. 500 to Rs. 1704 per qtl. The average modal price of pearl millet in almost all the years in Punjab received more than the minimum support price (MSP) fixed for pearl millet (Table 4). After 2013, Punjab's prices were closer to or sometimes below the MSP and the MSP has steadily increased over the years, after the year 2017. Maharashtra, Gujarat and Karnataka showed more consistent and often higher prices, suggesting better established markets for pearl millet (Kumar and Sonnad, 2023; Sachan and Shah, 2023; Gandhi *et al*, 2023).

Government initiatives play a pivotal role in shaping the prospects of agricultural crops. In recent years, various state and central government schemes have aimed at promoting the cultivation of millets, including pearl millet. Assured price, subsidies, financial incentives, and awareness programs have been implemented to encourage farmers to diversify their cropping patterns and reintegrate pearl millet into the agricultural landscape (Malik and Pawar, 2019).

Prospects

Based on projections of population growth and consumption patterns, the demand for pearl millet has been forecasted for the year 2025 to be 12.69 million quintals (Lal and Singh, 2016). These projections have taken into account factors that influence the consumption of these food grains, allowing us to estimate the expected demand in the future. Current production is around 10.86 mq and about two mq production of pearl millet is needed to be increased by 2025 as per this projections. Punjab being a traditional growing region of pearl millet, it can increase area under pearl millet and meet this growing demand provided the economic incentives are provided to farmers.

According to NSSO 66th round survey, pearl millet consumption in state was 0.0003 kg per month. Consumption in pearl millet was low but it use to export to other states of the country. Punjab use to export its surplus production to major producing and consuming states like Gujarat, Maharashtra and Rajasthan (Table 5). In future also Punjab can export its surplus production to other states as the demand for nutri-cereals has increased due to health consciousness among the consumers. Pearl millet was the most stocked millet variety followed by sorghum and finger millet by retailers. Other types of millets were stocked by only a few retailers.

In urban centres, particularly Tier 1 cities, millets are

Table 4. Average modal price and MSP of pearl millet through 2002 to 2020 **(Rs. /qtl)**

Year	Punjab	Gujarat	Maharashtra	Karnataka	MSP
2002	613.19	501.36	650.27	492.34	485
2003	839.68	687.33	654.10	500.21	505
2004	573.75	661.82	670.03	483.67	515
2005	604.62	707.96	662.61	499.24	525
2006	699.82	708.07	667.68	613.40	540
2007	1520.00	726.57	669.49	637.25	600
2008	840.39	720.23	672.84	622.00	840
2009	896.00	733.87	680.27	833.09	840
2010	1105.00	1028.64	935.62	857.14	880
2011	955.00	990.01	1114.01	982.43	980
2012	1385.00	1145.70	1297.93	1198.94	1175
2013	850.00	1373.77	1474.24	1407.39	1250
2014	1317.00	1223.19	1500.62	1285.08	1250
2015	1329.00	1254.07	1433.22	1375.66	1275
2016	NA	1573.53	1648.21	1633.64	1330
2017	1230.00	1318.90	1408.15	1386.45	1425
2018	1422.50	1376.81	1519.81	1343.6	1950
2019	NA	1956.30	2129.93	1999.36	2000
2020	NA	1721.65	1752.81	1532.61	2150

Source: AGMARKNET

experiencing a surge in popularity owing to their associated health benefits. Currently, millets are predominantly found in loose form across various cities and towns. However, a notable trend in supermarkets and hypermarkets reveals an increasing availability of branded millet products, both in organic and non-organic variants. Pearl millet appeared to be popular in the North and Eastern parts of India.

India's export of pearl millet shows an increasing trend in terms of both value and quantity over the observed time periods. The export value has risen from 14,942.3 thousand USD in triennium ending (TE) 2016-17 to 17,259 thousand USD in TE 2022-23. Saudi Arabia and UAE are the top importers of Indian pearl millet from TE 2016-17 to TE 2022-23 (Table 6). Both countries have shown consistent growth in import value, quantity, and unit values over time. Some emerging markets like Libya, Morocco, Yemen, Oman, Tunisia, Qatar, and Kuwait have exhibited increased demand for Indian pearl millet in recent years, as seen by the growing export value, quantity, and unit values. Bangladesh, though currently importing negligible quantities, has shown a substantial increase in unit value, indicating a potential market for Indian pearl millet (Table 6). Exploring this market further could be beneficial. South Africa has shown a stable demand for Indian pearl millet, with moderate growth in export value, quantity, and unit value. This market can be considered as a reliable destination for Indian exporters.

India's pearl millet export destinations can be made more diverse by exploring into and growing into new markets such as Libya, Morocco, Yemen, Oman, Tunisia, Qatar, and Kuwait. This can increase trade stability and lessen reliance

Table 5. Internal trade directions of pearl millet from Punjab

Particulars	Gujarat	Maharashtra	Rajasthan	Others	Total
1967-68	61000	21000	-	1000	83000
1968-69	17000	9000	40000	7000	73000
1969-70	38000	14000	77000	2000	131000

Source: Anonymous (1973)

Table 6. India's exports of pearl millet to major export destinations

	Importers	TE 2016-17			TE 2019-20			TE 2022-23		
		Value	Quantity	Unit value	Value	Quantity	Unit value	Value	Quantity	Unit value
	World	14942.3	53218735.0	0.283	12805	43006097	0.297	17259	53764329	0.320
1	Saudi Arabia	2330.3	8537333.3	0.273	2389.3	8280666.7	0.287	3909.3	12750860.0	0.303
2	UAE	2276.0	8710861.3	0.260	2769.7	9594040.3	0.287	3586.7	12972276.0	0.283
3	Libya	317.7	1021666.7	0.293	660.7	2071666.7	0.307	1320.7	3615633.3	0.353
4	Morocco	425.0	1519666.7	0.280	596.0	2060333.3	0.290	910.3	2748333.3	0.320
5	Yemen	2098.3	7946783.3	0.267	1644.3	6128333.3	0.270	920.7	3319026.7	0.270
6	Oman	192.7	644780.0	0.310	174.0	568213.3	0.313	735.0	2499591.0	0.290
7	Tunisia	567.3	1867756.0	0.303	662.3	2203000.0	0.297	879.3	2826666.7	0.307
8	Bangladesh	0.0	0.0	0.000	0.3	0.0	0.200	256.7	0.0	0.287
9	South Africa	142.0	411885.0	0.357	198.0	603071.7	0.327	291.3	700621.0	0.380
10	Qatar	128.7	481333.3	0.263	180.3	640868.3	0.280	451.3	1531834.0	0.290
11	Kuwait	133.7	493420.0	0.270	146.0	468390.7	0.317	285.0	815762.0	0.327
12	Bahrain	111.3	401000.0	0.277	197.0	672116.7	0.293	346.0	1088583.3	0.310
13	UK	269.0	686062.7	0.393	371.0	853544.3	0.433	557.3	1200456.7	0.467
14	Algeria	46.7	264000.0	0.265	421.7	1399000.0	0.307	411.0	1253333.3	0.320
15	Japan	293.0	678333.3	0.433	129.3	384666.7	0.377	314.0	635701.7	0.497

Note: Value in '000 USD; Quantity in kgs; Unit value in USD/Kg

Table 7. India's export potential of pearl millet **(in million USD)**

	Export destinations	Export potential	Actual exports	Unrealised potential	Major competitors
1	Indonesia	9.2	0.016	9.2	USA, Russia, Ukraine, Canada and China
2	Nepal	7.5	5.2	2.3	NA
3	USA	2.4	0.485	1.9	China, Canada and France
4	Korea	1.5	0.097	1.4	China, USA, Ukraine, and Australia
5	Germany	1.5	0.034	1.4	Ukraine, China, France, Poland and Austria
6	Turkiye	1.2	0.012	1.2	Russia, Uzbekistan, Kazakhstan, Ukraine and China
7	South Africa	1.7	0.591	1.1	Russia, Ukraine, Romania
8	Iraq	1.1	0.021	1.1	NA
9	Philippines	0.925	0.011	0.914	USA, Ukraine, Russia, China, and Germany
10	Thailand	1	0.182	0.868	Ukraine, Russia, Australia and China

on a small number of countries. It is crucial to concentrate on sustainable agricultural methods and guarantee the quality and safety of Indian pearl millet in order to keep a competitive edge in international markets. This can be accomplished by putting in place efficient certification programs and regulatory requirements. Pearl millet exports from India have a large market potential in countries like Indonesia, Nepal, the United States, Korea, Germany, Turkiye, South Africa, Iraq, the Philippines, and Thailand (Table 7). Initiatives for export promotion and market growth plans must centre on these markets. There is an opportunity for expansion and an increase in the market share of Indian pearl millet in a number of markets where it is currently underutilized. To bridge this gap, targeted marketing initiatives, better trade facilitation, and removal of trade obstacles should all be used.

Bridging the profitability gap: A comparative analysis of paddy and pearl millet cultivation in Punjab

The results obtained using breakeven point and feasibility analysis is presented in Table 8. From the simulation analysis,

Table 8. Breakeven point and feasibility analysis of paddy & pearl millet cultivation in Punjab

Parameter	Paddy	Pearl millet (Current)	Pearl millet (Equal Profitability)	Pearl millet (Simulated for 10% increase in profitability)
Operational cost (Rs/ha)	48,255.1	35,511.2	35,511.2	35,511.2
Yield (qtl/ha)	69.8	6.4	60.17	64.54
Price (Rs./qtl)	2,036.1	1984.37	2,150	2,150
Gross returns (Rs./ha)	142,119.5	12,700.0	129,375.6	138,761.0
Net returns over operational cost (Rs./ha)	93,864.4	-22811.2	93,864.4	103,249.8
B:C Ratio (Over operational cost)	2.9	0.5	3.64	3.9
Yield increase required (%)	-	-	840.16	908.44
Highest reported yield in India (qtl/ha)	-	20-25	-	-
Global high-yielding varieties (qtl/ha)	-	40-50	-	-

it is concluded that in order to make pearl millet cultivation profitable than paddy with 10 per cent increase in profitability compare to paddy, the required yield is 65 quintals per ha (Table 8). However, it's not possible to increase the yield as the highest pearl millet yields in India are around 20-25 qtl/ha in states like Gujarat and Haryana, the global level high-yielding pearl millet varieties can produce up to 40-50 qtl/ha under optimal conditions.

Therefore, in order to make pearl millet competitive with paddy, a multi-pronged approach would be needed like first of all development of high-yielding varieties suited to Punjab's climate, improvement in cultivation practices and inputs and reduction in operational costs through mechanization or other efficiencies. Policy interventions such as price supports, subsidies, or incentives for water-saving crops could help bridge the profitability gap while yields are being improved.

Conclusion and Policy Implications

To sum up, the study emphasizes the importance of promoting and supporting pearl millet cultivation in Punjab as a means of achieving sustainable agriculture in the region. Pearl millet is a valuable crop with high nutritional value and tolerance to drought and poor soil fertility, making it an ideal candidate for crop diversification. However, the evidence from the study has suggested that pearl millet cultivation has been marginalized in recent years due to the intensive paddy-wheat system. From the breakeven point and feasibility analysis, it's revealed that for pearl millet to be more profitable than paddy, a yield of 69.9 qtl/ha is needed; achieving this yield is not feasible with current technologies and practices. Our research stressed that to address this issue, policymakers and stakeholders must invest in research and development to improve the yield and quality of pearl millet production. This can include developing and promoting high-yielding varieties, adopting advanced agricultural practices, and ensuring compliance with international standards to increase its exports. By providing farmers with training and technical assistance, improving access to credit and agricultural inputs, and raising awareness about the nutritional benefits of pearl millet, we can facilitate the resurgence of pearl millet cultivation and lead to crop diversification in Punjab.

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