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AN IN-DEPTH EXAMINATION OF GLOBAL PULSE PRODUCTION: TRENDS, FACTORS, AND IMPLICATIONS

B.Kavisri
Ph.d Research Scholar, Department of Commerce, Annamalai University, Annamalainagar – 608002, kavisri12062000@gmail.com

J.Sundararaj
Associate Professor in Commerce, Annamalai University, Annamalainagar – 608 002. sundararaj30@gmail.com

Abstract
Pulses stand as integral components of global agriculture, not solely due to their nutritional prowess as primary protein sources, but also owing to their pivotal role in fostering agricultural sustainability. Legumes, renowned for their nitrogen-fixing abilities and efficient water usage, demand fewer inputs compared to other crops, thereby enhancing agricultural resilience. This abstract encapsulates the exponential growth witnessed in pulse cultivation, with global acreage surging from 71.59 million hectares in 2002 to 94.18 million hectares in 2021. Correspondingly, pulse production soared from 58.14 million tons to 90.96 million tons during the same period, attesting to their escalating significance in global food systems. Notably, key pulse-producing nations including India, Canada, Myanmar, and China, among others, feature prominently in this landscape, underscoring their collective contribution to meeting global dietary demands and advancing agricultural sustainability goals.
Keywords: Pulses, production, Area, Countries, agricultural resilience, Pulse Production, Trends, Factors

Introduction
Pulses, encompassing an array of leguminous crops such as lentils, peas, and chickpeas, stand as indispensable nutritional powerhouses, enriching diets with essential nutrients and bioactive compounds critical for human health. Laden with protein, carbohydrates, and dietary fiber, pulses constitute a cornerstone of balanced nutrition across cultures worldwide. Defined as the edible seeds of plants within the legume family, pulses include a diverse array of varieties such as Bengal gram, Red gram, Green gram, Black gram, and Horse gram, each offering unique culinary and nutritional profiles [1]. In nations like India, where vegetarianism prevails among the populace, pulses emerge as a lifeline, serving as a primary source of protein and sustenance. Beyond their nutritional prowess, pulses wield ecological significance, thanks to their capacity to harness atmospheric nitrogen, thus bolstering soil fertility and promoting sustainable agricultural practices[2].

The global pulse landscape is dominated by key producing nations, including India, Canada, Myanmar, and China, among others, whose agricultural prowess significantly influences global food security and trade dynamics [3]. The cultivation of pulses is underpinned by favorable climatic conditions and soil suitability, facilitating optimal yields and substantial revenue generation for growers and governments alike. Moreover, the pulse sector serves as an engine of economic growth and employment, offering livelihood opportunities to rural communities engaged in cultivation, harvesting, and processing activities. Recent years have witnessed a surge in pulse production globally, attributed to advancements in agricultural technologies, improved agronomic practices, and supportive policy frameworks, culminating in enhanced yields and financial returns for growers worldwide [4].

As we delve deeper into the multifaceted realm of pulse production, it becomes evident that these humble legumes not only nourish bodies but also nurture ecosystems and livelihoods, underscoring their profound significance in shaping sustainable food systems and fostering inclusive economic development on a global scale [5].

Statement of the Problem

The global yield of pulses has encountered numerous challenges in recent times, influenced by a confluence of factors spanning environmental, climatic, and socio-economic realms. Extensive deforestation in key pulse-producing regions has disrupted ecological balances, leading to soil degradation and loss of biodiversity, thereby impeding optimal crop growth and yield. Moreover, erratic monsoon patterns, exacerbated by climate change, have intensified water stress, hampering the productivity of pulse crops reliant on adequate moisture levels for optimal development.

Compounding these challenges is the scarcity of high-yielding variety seeds tailored to the specific agro-climatic conditions prevalent in pulse-growing regions. The limited availability of quality seeds constrains farmers' ability to maximize yields and adapt to changing environmental conditions effectively. Additionally, fertilizer scarcity poses a significant impediment to pulse cultivation, as inadequate nutrient supplementation can compromise crop health and productivity. Furthermore, the prevailing trend of low produce prices undermines the economic viability of pulse farming, discouraging investment in inputs and technologies essential for enhancing yields and profitability. Inadequate knowledge and awareness among farmers regarding optimal seed rates, coupled with variations in soil moisture levels and infrequent rainfall, further exacerbate yield fluctuations and production uncertainties.

The recurring incidence of droughts, intensified by climate variability, poses a persistent threat to pulse cultivation, with water scarcity severely compromising crop growth and yield potential. In light of these multifaceted challenges, this study endeavors to provide a comprehensive overview of pulse cultivation practices worldwide, shedding light on the complexities and nuances shaping the global pulse production landscape. Through a thorough examination of the factors influencing pulse yield variability, this study aims to inform evidence-based interventions and strategies aimed at enhancing the resilience and sustainability of pulse farming systems globally [6-8].

Objective of the Study

Objective of the study "An In-depth Examination of Global Pulse Production: Trends, Factors, and Implications":

Analyze Trends: To comprehensively analyze the historical and current trends in global pulse production, including variations in production volumes, shifts in geographical distribution, and emerging market dynamics.

Identify Factors: To identify and assess the multifaceted factors influencing pulse production on a global scale, encompassing agronomic practices, technological advancements, climatic variability, market dynamics, policy interventions, and socio-economic considerations.

Evaluate Implications: To evaluate the implications of pulse production trends and factors for key stakeholders, including farmers, consumers, policymakers, and the broader agricultural sector, with a focus on food security, environmental sustainability, economic development, and social equity.

Understand Resilience: To understand the resilience of pulse production systems in the face of challenges such as climate change, resource constraints, market volatility, and socio-economic disparities, and identify strategies for enhancing resilience and adaptability.

Inform Decision-making: To provide evidence-based insights and recommendations to inform decision-making by policymakers, agricultural stakeholders, and researchers, aimed at fostering sustainable growth, enhancing productivity, promoting inclusive development, and addressing challenges within the global pulse production landscape.

Area in Pulses: World Scenario

In addition to being a significant source of protein and having high nutritional value, pulses are crucial to global agriculture because they help to ensure its sustainability. In terms of sustainability, pulses fix atmospheric nitrogen (N) and require less water and inputs. Worldwide, the area planted for pulses increased from 71.59 million hectares in 2002 to 94.18 million hectares in 2021. Production also increased in tandem, rising from 58.14 million tonnes in 2002 to 90.96 million metric tonnes in 2021. The protein content of pulses is 20–25% higher by weight than that of wheat and 3 times higher than that of rice. The production of pulses has increased dramatically worldwide over the last forty years. The world has produced between 58 and 91 million tonnes of pulses annually in just the last 20 years. Between 2002 and 2021, nearly 173 countries worldwide grew and exported pulses. Table 1 displays the cultivating area of pulses in the major producing countries during this time [9].

Table 1 shows that during the study period, the cultivated area of pulses has been gradually growing in line with the industrialized countries such as the USA, China, Japan, and Europe's ever-increasing demand for pulses. It was caused by a rise in both domestic and foreign demand as a result of the governments of the countries that cultivate pulses working together systematically. According to country-specific area data, between 2002 and 2021, the Asian countries of India, China, Myanmar, and Turkey accounted for 43.93% of the total area. Except for 2009, these Asian nations demonstrated an upward trend in the region. India saw a trend toward gradual decline, which translated into a total decrease of 69.77 million hectares in aggregate area. The primary pulse-growing states of Rajasthan, Madhya Pradesh, and Maharashtra experienced heavy rains and flooding, which contributed to the decline in the Indian area [10].

India holds a significant portion of the global area and production of pulses, with 33.83% of the world's area and 24.66% of production from 2002 to 2021. The country accounts for 90% of the global area under pigeon pea, 65% under chickpeas, and 37% under lentils, with corresponding production shares of 93%, 68%, and 32% respectively. Despite this, the growth rate of pulse crop area has been minimal at 2.80% during the study period, leading to a decrease in the share of pulses in total food grain production from 3.41% in 2002 to 2.98% in 2021. Climate change has also impacted areas like Nigeria, leading to a decrease in 2009. Climate-related threats such as extended dry seasons, floods, and soil degradation are becoming more common, posing a serious threat to agricultural livelihoods and food security. The distribution of pulse cultivating countries in terms of area from 2002 to 2021 can be seen in Figure 1 [11].

TABLE 1

Pulses Cultivating Countries (Area) during 2002-2021 (Area in Million ha)

Year	Pulses Cultivating Countries (Area)														
	India	Canada	China	Myanmar	Nigeria	Russian Federation	Brazil	Ethiopia	Niger	Australia	Mexico	Turkey	Others	Total Cultivation Area	Increase/ Decrease	Percentage of Increase/ Decrease
2002	22.18	3.54	2.74	2.49	4.26	0.72	2.72	0.16	3.45	1.42	1.64	0.83	25.44	71.59	-	-
2003	22.2	2.4	3.26	2.57	4.28	0.76	3.71	0.18	3.47	1.46	0.06	0.51	27.25	72.11	0.52	0.72
2004	22.22	2.41	3.29	2.62	4.32	0.79	3.72	0.2	3.5	1.48	0.08	0.53	25.55	70.71	-1.4	1.97
2005	22.26	2.43	3.31	2.65	4.34	0.8	3.74	0.21	3.52	1.51	0.09	0.55	26.14	71.55	0.84	1.17
2006	22.27	2.45	2.94	2.72	4.36	0.84	3.78	1.43	3.53	1.54	0.11	0.56	26.84	73.37	1.82	2.48
2007	22.7	2.46	2.96	2.81	4.4	0.96	3.8	1.46	3.56	1.56	0.18	0.59	27.92	75.36	1.99	2.64
2008	22.8	2.45	2.99	3.83	4.41	0.98	3.82	1.51	5.31	1.52	1.63	0.92	21.22	73.39	-1.97	-2.68
2009	20.9	2.6	2.76	3.95	2.59	0.93	4.14	1.57	4.22	1.44	1.31	0.9	22.46	69.77	-3.62	-5.18
2010	26.1	2.86	2.82	3.78	2.62	1	3.5	1.48	5.64	1.74	1.75	0.89	24.74	78.92	9.15	11.59
2011	26.5	2.89	2.84	3.8	2.69	1.04	3.52	1.49	5.69	1.76	1.77	0.9	24.91	79.8	0.88	1.1
2012	27.18	2.9	2.86	3.86	3.31	1.06	3.59	1.5	5.7	1.78	1.78	0.92	23.81	80.25	0.45	0.56
2013	28.1	2.42	2.88	3.88	3.33	1.7	2.85	1.58	4.84	1.91	1.8	0.94	24.49	80.72	0.47	0.58
2014	30.3	2.87	2.38	4.2	3.84	1.76	3.2	1.59	5.47	1.96	1.83	0.98	22.19	82.57	1.85	2.24

2015	26.99	3.28	2.4	4.29	3.7	1.79	2.89	0.22	5.06	2.06	1.68	0.74	30.5	85.6	3.03	3.54
2016	30.75	4.06	2.61	4.31	4.96	1.8	2.61	0.22	5.34	2.49	1.68	0.74	25.73	87.3	1.7	1.95
2017	34.73	3.62	2.7	4.36	5.16	1.89	2.83	0.22	6.01	2.83	1.76	0.83	18.66	85.6	-1.7	1.99
2018	36.4	3.24	2.76	3.78	3	2.63	2.87	0.18	6.06	2.5	1.83	0.92	21.13	87.3	1.7	1.95
2019	30.82	3.51	2.71	4.21	4.54	2.69	2.64	0.17	5.88	1.66	1.34	0.94	27.59	88.7	1.4	1.58
2020	33.1	3.69	2.64	4.32	4.84	1.9	2.72	1.59	1.59	1.77	1.67	0.87	32.48	93.18	4.48	4.81
2021	33.4	3.7	2.66	4.33	4.88	1.92	2.74	1.6	1.6	1.78	1.78	1.68	32.11	94.18	1	1.06
Total	**541.9**	**59.78**	**56.51**	**72.76**	**79.83**	**27.96**	**65.39**	**18.56**	**89.44**	**36.17**	**25.77**	**16.74**	**511.16**	**1601.97**		
Average	**27.1**	**2.99**	**2.83**	**3.64**	**3.99**	**1.4**	**3.27**	**0.93**	**4.47**	**1.81**	**1.29**	**0.84**	**25.55**	**80.09**		
Per cent Share	**33.83**	**3.73**	**3.52**	**4.54**	**4.98**	**1.75**	**4.08**	**1.16**	**5.58**	**2.26**	**1.61**	**1.04**	**31.92**	**100**		
Rank	**1**	**6**	**7**	**4**	**3**	**9**	**5**	**11**	**2**	**8**	**10**	**12**				
CGR	**2.8**	**2.1**	**1**	**3.1**	**0.4**	**7.1**	**1.8**	**2**	**0.2**	**2.3**	**15.5**	**3.3**	**0.2**	**1.8**		

Source : Source: wwwagricoop.nic.in

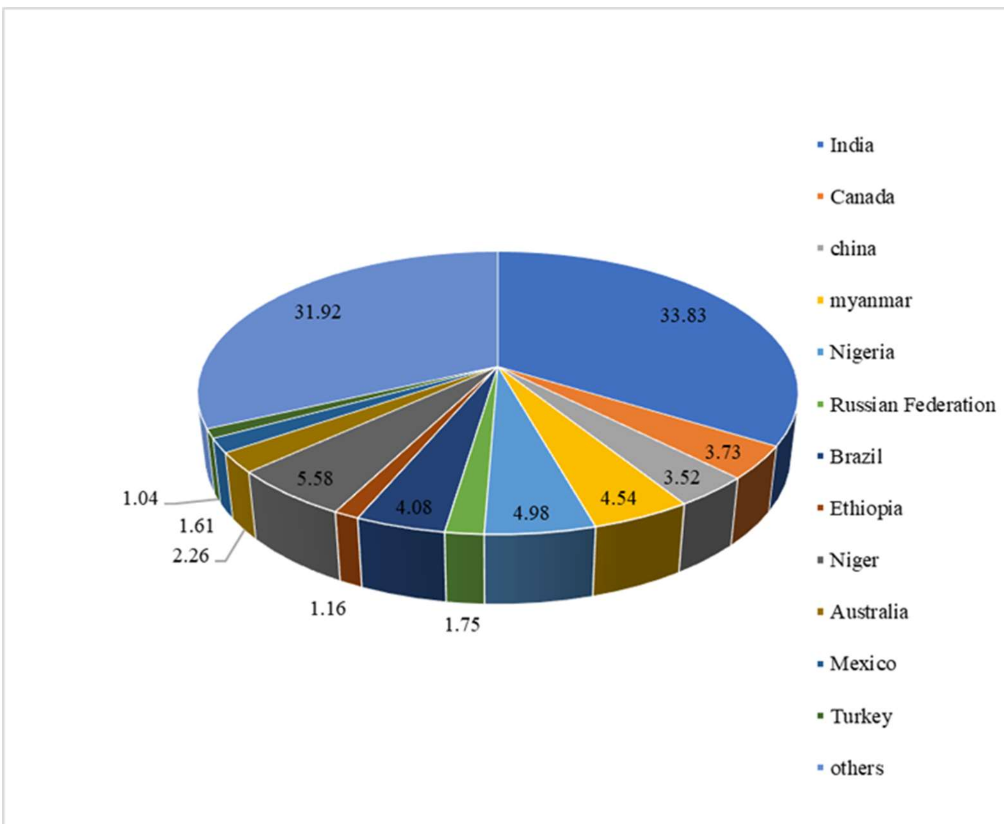

FIGURE 1
Pulses Cultivating Countries (Area) during 2002 - 2021

Production of Pulses in the World

For many people, pulses are a crucial component of their nutritional security. In many developing nations, they are a significant source of protein, particularly for the less fortunate populations who primarily get their protein and energy from vegetables. Furthermore, pulse consumption has changed recently in many developed nations as a result of their growing reputation as health foods. On December 20, 2013, the United Nations General Assembly, in its sixty-eighth session, proclaimed 2016 as the International Year of Pulses. The United Nations Food and Agriculture Organization (FAO) has been proposed to designate a year for pulses. Pulses are the second most important crop group in the world, after cereals. In 2021, 94.18 million hectares of land yielded 90.96 million tonnes of pulses, with an average yield of 966 kg per ha. India accounts for approximately 25–28% of the world's total production of pulses, including 90% of red gram, 75% of Bengal gram, and 37% of lentil area. India is also the world's largest producer and consumer of pulses. For the great majority of Indians, pulses are the mainstay of their diets because, when combined with cereals, they offer the ideal balance of vegetarian protein components with high biological value. The nation cultivates a wide range of pulse crops, including lentils, dry peas, red, green, and black grams, among others. in a variety of agroclimatic circumstances. Table 2 displays the pulse production in the main producing nations from 2002 to 2021 [12-15].

TABLE 2

Pulses Production in the Major Producing Countries during 2002-2021 (Production in Millions Tonnes)

Year	Pulses Producing Countries									
	India	Canada	China	Myanmar	Nigeria	Russian Federation	Brazil	Ethiopia	Niger	Australia
2002	13.12	4.29	4.43	2.39	2.76	1.48	3.00	1.53	1.32	0.50
2003	13.18	4.68	4.55	2.44	2.79	1.52	3.01	1.59	1.39	0.80
2004	13.20	4.76	4.62	2.49	2.82	1.59	3.02	1.62	1.40	0.10
2005	13.75	4.81	4.79	2.57	2.86	1.63	3.03	1.68	1.42	0.11
2006	13.82	4.86	4.82	2.53	2.89	1.69	3.14	1.70	1.49	1.63
2007	14.00	4.92	4.86	2.54	2.92	1.75	3.24	1.72	1.52	1.70
2008	14.00	4.94	4.89	4.52	2.96	1.82	3.48	1.77	1.57	1.72
2009	14.10	5.18	4.33	4.40	2.41	1.57	3.51	1.84	1.81	1.80
2010	17.10	5.19	4.47	4.39	2.28	1.39	3.22	1.80	1.83	1.90
2011	17.50	5.23	4.52	4.41	2.33	1.54	3.29	1.83	1.86	1.94
2012	17.80	5.69	4.56	4.42	2.42	1.89	3.32	1.85	1.86	1.98
2013	18.30	6.10	4.47	5.43	2.56	2.08	2.94	1.99	1.73	2.70
2014	17.91	5.82	4.11	5.97	2.20	2.29	3.30	2.61	1.75	2.24
2015	18.14	6.07	4.17	6.22	2.37	2.32	3.09	3.52	2.05	2.34
2016	23.75	8.34	4.53	6.46	3.82	2.39	2.63	3.48	2.03	4.72
2017	23.75	7.08	5.02	6.62	3.94	2.42	3.06	3.58	2.46	3.07
2018	25.40	6.32	5.03	6.68	3.57	3.43	3.30	3.09	2.47	2.74
2019	21.51	6.98	4.85	6.89	3.65	3.43	2.92	3.26	2.72	1.92
2020	23.30	8.16	4.80	4.02	3.71	3.44	3.05	2.99	2.82	1.91
2021	24.01	8.18	4.10	4.04	3.82	3.46	3.08	2.10	2.85	1.95
Total	**333.63**	**109.42**	**87.82**	**85.39**	**55.26**	**39.67**	**59.55**	**43.45**	**35.50**	**35.82**
Average	**16.69**	**5.47**	**4.40**	**4.27**	**2.76**	**1.98**	**2.98**	**2.17**	**1.78**	**1.79**
Per cent Share	**24.66**	**8.10**	**6.50**	**6.32**	**4.09**	**2.93**	**4.40**	**3.21**	**2.62**	**2.64**
Rank	**1**	**2**	**3**	**4**	**6**	**8**	**5**	**7**	**10**	**9**
CGR	**3.90**	**3.20**	**0.10**	**5.40**	**1.60**	**4.80**	**0.20**	**4.30**	**4.10**	**11.70**

Source : Source: wwwagricoop.nic.in CGR = Compound Growth Rate (Computed)

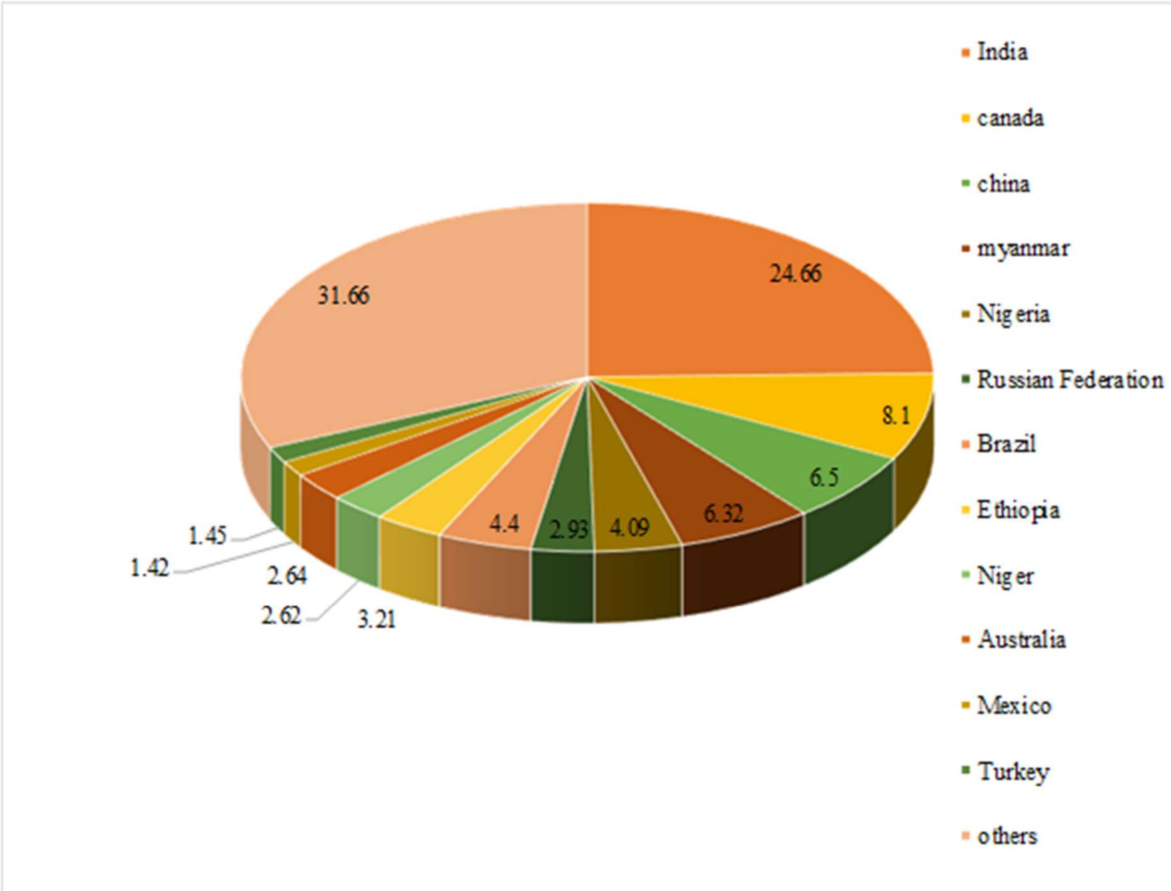

FIGURE 2
Pulses Production in the Major Producing Countries during 2002-2021

The total amount of pulses produced worldwide in 2021 has nearly doubled in the last 20 years (2002–2021), surpassing 90,096 million tonnes for the first time in history. There was variation in growth over this period, despite the overall upward trend in global production. Although it expanded at a comparatively rapid rate between 2002 and 2010 (9.12% p.a.), output virtually stopped after that. The developed countries led the growth in 2002, increasing their output from 58.14 million tonnes in 2002 to 90.96 million tonnes in 2021, an annual growth rate of 42.47 percent. Additional investigation reveals that if the transition economies' declines had not occurred, the developed countries' production growth between 2002 and 2021 would have been substantially higher. In 2002, the total production of pulses in these nations decreased by 12 percent per year, which was consistent with the overall pattern of their agricultural output after undergoing economic reforms. According to the data, industrialized nations' share of the global pulse production has doubled, rising from 1.98 percent in 2002 to 9.12 percent in 2010. The percentage of pulse production has decreased since 2011 [16]. The reasons for this decline are as follows: (a) most of the production in developing nations is for subsistence, whereas in developed nations it is commercial; (b) there has been little investment in pulse cultivation because it is typically a small-scale endeavor and is not thought to be a profitable industry; (c) the expansion of irrigated land has forced pulses into marginal zones, with better land being used to grow cereals; (d) an agricultural policy that prioritizes cereals to ensure food security; and (e) little research, lack of technology, and limited availability of improved cultivars to farmers. The amount of pulses consumed per person in developing nations decreased sharply in certain areas, particularly in Asia and sub-Saharan Africa, while overall consumption stagnated. These trends show shifting consumer preferences and dietary habits, but they also show that domestic production has not been able to keep up with population growth in many countries. This was frequently the outcome of the government's desire to boost cereal production and self-sufficiency. As a result, there has been a decrease in per capita pulse production, which is indicative of domestic source availability. Figure 2 depicts the production of pulses in the major producing nations.

Conclusion

In order to overcome current obstacles and seize new opportunities, research endeavors must go forward with a focus on improving pulse production methods. This means that agronomic measures including crop rotation, intercropping, and the creation of creative pulse-cereal complementary cropping systems must be strategically prioritized in order to maximize their effectiveness. Farmers may reduce risks, promote sustainability, and improve soil health and overall agricultural output by including pulses into varied cropping systems. Improved farmer training and capacity-building programs are also desperately needed in order to provide farmers with the information and abilities required for effective pulse farming. Essential elements of training programs should include methods for preparing the soil, best procedures for planting and harvesting, prudent use of agrochemicals, and the use of cultivars resistant to disease. Furthermore, farmers need to be equipped with the knowledge and resources necessary to carry out thorough analyses of the possible expenses, yield fluctuations, hazards, and financial returns related to incorporating pulse crops into their cropping systems.

Stakeholders may encourage the use of best practices in pulse production and assist informed decision-making by guaranteeing that farmers have sufficient training and information. In the end, these coordinated initiatives are essential to realizing pulse crops' full promise for improving food security, advancing sustainable agriculture, and stimulating economic growth for farming communities across the globe.

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