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Constraint Dynamics in Rainfed Pulse Farming: A Case of the Seed Hub Project in India

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Abstract: As the world's largest producer and consumer of pulses, India faces a persistent paradox: despite its central global role, national pulse productivity remains hindered by a range of biophysical, socio-economic, and institutional challenges. This study highlights the significant constraints limiting pulse productivity, drawing insights from farmers in the Nagaur district of Rajasthan, where a pulse seed hub has been established by the Ministry of Agriculture and Farmers Welfare at KVK, Nagaur, under the administrative control of Agriculture University, Jodhpur. The findings reveal that abiotic challenges are the most severe, with farmers reporting acute limitations due to lack of irrigation, extreme temperatures, and terminal drought. Resource-related constraints such as labor scarcity and inadequate access to credit further aggravate production difficulties. Marketing issues, including high transportation costs and the prevalence of unregulated markets, also restrict farmers' ability to benefit from pulse cultivation. The study indicates that farmers with higher education, higher income, larger landholdings, and stronger social participation tend to perceive fewer constraints. This demonstrates the crucial role of socio-economic empowerment in managing production challenges. Given these realities, there is an urgent need for targeted interventions that focus on improving irrigation infrastructure, enhancing credit accessibility, developing resilient pulse varieties, and strengthening market linkages, particularly for small and marginal farmers. Strengthening farmers' organisations and institutional support systems is imperative for enhancing pulse productivity and enabling India to fully realize its potential as the global leader in pulse production.

Key words: Seed hub, pulses, constraints, partner, and fellow farmers.

Diverse cropping systems, with pulses as a crucial component, are practiced in India to ensure food and nutritional security. With 25% of global pulse production and 27% of consumption, India is a leading producer and consumer of pulses (Meena *et al*., 2024). Quality seed availability requires special attention to make India self-sufficient in pulse production through productivity enhancement. Lack of quality seed, particularly for pulses, is a significant barrier to achieving self-sufficiency in pulse production. Approximately 250000 to 300,000 tons of high-quality seed are required annually to achieve a 30% seed replacement rate and increase pulse crop yield and productivity (Kandir *et al*., 2021). The geographical location of Rajasthan as an arid and semi-arid region presents unique challenges and opportunities for pulse production. The diverse agro-climatic zones in Rajasthan, ranging from the extremely arid western districts to the relatively humid eastern regions, create a complex production environment that significantly influences pulse productivity and sustainability (Hussain, 2015).

Despite being one of the leading pulse-producing states, Rajasthan faces numerous constraints that limit its potential to achieve optimum production levels. The state's pulse production systems are predominantly rainfed, making them highly vulnerable to climatic variability and environmental stresses that characterize the region's agricultural landscape (Govindaraj *et al*., 2024). Goswami *et al*. (2024) stated that in arid and semi-arid regions, the precipitation data often display significant discrepancies due to highly irregular rainfall patterns, making drought assessment and management critical for pulse production in Rajasthan. Understanding and addressing these constraints is crucial for developing effective strategies to enhance pulse production in Rajasthan, which can contribute significantly to India's goal of achieving self-sufficiency in pulse production. Recent studies by Lybbert *et al*. (2024) on pulse production in India emphasize the need for an extensive analysis of production challenges and a strategic vision for 2030. However, realizing this potential entails an inclusive understanding of the existing constraints and the development of targeted interventions to overcome them. Therefore, a study was undertaken to measure the prevailing constraints in pulse production.

Materials and Methods

The present study was conducted in the Nagaur district of Rajasthan state, India. The district was selected purposively for this research because Nagaur hosts the only pulses seed hub at Krishi Vigyan Kendra, Nagaur, under the jurisdiction of the Agricultural University, Jodhpur. A two-stage purposive sampling technique was employed to select the respondents. In the first stage, all nine partner farmers actively involved in seed production activities with the KVK, Nagaur, were purposively selected for the study. These partner farmers represented the progressive farmers engaged in participatory seed production programs with the KVK, Nagaur. In the second stage, using the snowball non-probability sampling method, nine fellow farmers were selected from each partner farmer's network. This sampling strategy resulted in 81 fellow and nine partner farmers, constituting a sample size of 90 farmers. Data were collected using an interview schedule that was pre-tested and validated prior to data collection. Data was collected through face-to-face interviews with partners and fellow farmers during 2024-25. The constraints in pulse production were systematically categorized into four major categories based on their nature and impact on production systems: (i) abiotic, (ii) crop management and growth related, (iii) bio-physical, (iv) resource related, and (v) marketing. The responses regarding the severity of constraints were obtained using a three-point Likert-type scale, which indicated the degree to which each constraint was experienced by the farmers. The scale consisted of three three-point continuums for the responses, ranging from very serious to severe to less severe, for which values 3, 2, and 1 were assigned. The mean percent score for each constraint was calculated. The MPS values were used to rank the constraints in order of severity as perceived by the farmers. An association between farmers' profiles and the severity of constraints was undertaken.

Results and Discussion

Based on the mean per cent score (MPS), the constraints faced by partners and fellow farmers were classified into five categories: abiotic, crop management, resource-related, bio-physical, and marketing (Table 1). MPS

Table 1. Ranking of constraints faced by the partner and fellow farmers

Sl. No.	Constraints	Partner farmers (n_1=9)		Fellow farmers (n_2=81)	
		MPS	Rank	MPS	Rank
A.	Abiotic				
i	Lack of irrigation	100.00	I	99.18	I
ii	Extreme temperature	100.00	I	95.06	II
iii	Soil hardiness after seed sowing	96.30	III	83.95	III
iv	Terminal drought	85.19	IV	83.54	IV
v	Soil cracking	77.78	V	73.66	V
vi	Low organic matter in the soil	77.78	V	73.25	VI
vii	Low residual moisture	74.07	VII	67.49	VII
viii	Damage by wind	70.37	VIII	66.26	VIII
B.	Crop management and growth-related				
i	Poor seed germination	66.67	I	66.67	I
ii	Short sowing period due to late monsoon	51.85	II	53.91	II
iii	Lack of short-duration varieties	40.74	III	38.68	III
C.	Resource-related				
i	Scarcity of human labor during sowing and harvesting	100.00	I	100.00	I
ii	Lack of credit for the purchase of inputs	59.26	II	82.72	II
iii	Lack of improved varieties	33.33	III	35.80	III
D.	Bio-physical				
i	Lack of proper storage facilities at harvesting time	100.00	I	99.59	I
ii	Erratic rainfall	96.30	II	98.35	II
iii	Non-availability of bio-fertilizer	81.48	III	93.83	III
iv	Excessive weed growth	70.37	IV	90.95	IV
v	Imbalanced use of chemical fertilizers	59.26	V	70.37	V
vi	Non-availability of herbicides	51.85	VI	69.14	VI
vii	Lack of soil testing facilities	48.15	VII	68.72	VII
viii	High infestation of pests and disease	44.44	VIII	41.56	VIII
E.	Marketing				
i	High transport cost	100.00	I	99.18	I
ii	Lack of a regulated market	44.44	II	98.77	II
iii	Lack of knowledge of the minimum support prices	40.74	III	89.30	III
iv	A large number of middlemen	33.33	IV	85.60	IV
v	Distress sells	33.33	IV	59.67	V
vi	Price fluctuation	33.33	IV	56.79	VI
vii	Collusion among traders in reducing prices	33.33	IV	51.03	VII

is a method for expressing respondents' performance as a percentage of the maximum possible score. MPS shows the average score a respondent (or group) achieved on the total possible score, making results easy to compare across individuals, groups, or variables. The average comparative depiction of constraints is shown in Fig. 1.

Abiotic constraints: Pulse crops are highly sensitive to abiotic stresses, which substantially limit their productivity across dryland and rainfed regions. Partner and fellow farmers identified a lack of irrigation and extreme temperatures as the most critical abiotic constraints (MPS ~100). Soil-related issues, such as soil hardiness, terminal drought, and soil cracking, were identified as prominent constraints (MPS = 96.30). These findings align with earlier studies on moisture stress and temperature fluctuations in pulse-growing areas of arid and semi-arid zones (Rao *et al.*, 2023). Adopting micro-irrigation, mulching, and soil-moisture conservation practices is crucial (Pandey *et al*., 2021). Pixley *et al*. (2023) emphasized that developing drought-tolerant and heat-resilient pulse varieties is crucial for sustaining yields under climate stress.

Crop management and growth-related constraints: It is evident from Table 1 that poor seed germination, narrow sowing windows due to delayed monsoon onset, and the absence of short-duration varieties were consistently reported constraints. It is worth mentioning that almost similar responses (MPS) regarding prevailing crop management and growth-related constraints were received from the partner and fellow farmers. The MPS range was found from 38.68 to 66.67. These challenges reflect the high climatic variability of Rajasthan's drylands and the slow pace of varietal improvement. Similar constraints have been documented in pulse crops, underscoring the need for climate-smart crop planning (Chaturvedi *et al*., 2018; IIPR, 2020; Verma *et al*., 2025). In this context, developing and disseminating short-duration, climate-resilient varieties, supported by real-time weather-based advisories, remains a critical strategy for stabilizing productivity (Jat *et al*., 2017).

Resource-related constraints: Resource-related constraints in pulse production, such as limited access to irrigation, labor scarcity, poor soil fertility, and other factors, adversely affect pulse productivity. Based on MPS, the constraints have been categorised (Table 1). In the present study, partners and fellow farmers ranked the scarcity of human labor during sowing and harvesting as a prominent constraint. Lack of credit and unavailability of improved varieties were also rated significant constraint. Labor bottlenecks and credit inaccessibility have been highlighted as major constraints to timely farm operations and the adoption of technology in pulses (Kumar *et al*., 2023; NABARD, 2020; Murthy *et al*., 2024). Villalba *et al*. (2024) suggested that promoting mechanization through custom hiring centres and institutional credit tailored for smallholders can reduce these limitations.

Bio-physical constraints: Pulses face significant biophysical constraints due to erratic rainfall, drought, and high temperatures, which cause flower drop and low yields. Poor soil fertility, shallow root systems, and high susceptibility to pests and diseases further limit their productivity. Based on the severity, the constraints have been documented in Table 1. Under bio-physical constraints, inadequate storage facilities were rated as the most prominent, followed by erratic rainfall, and the non-availability of biofertilizers and herbicides highlights infrastructural and service delivery

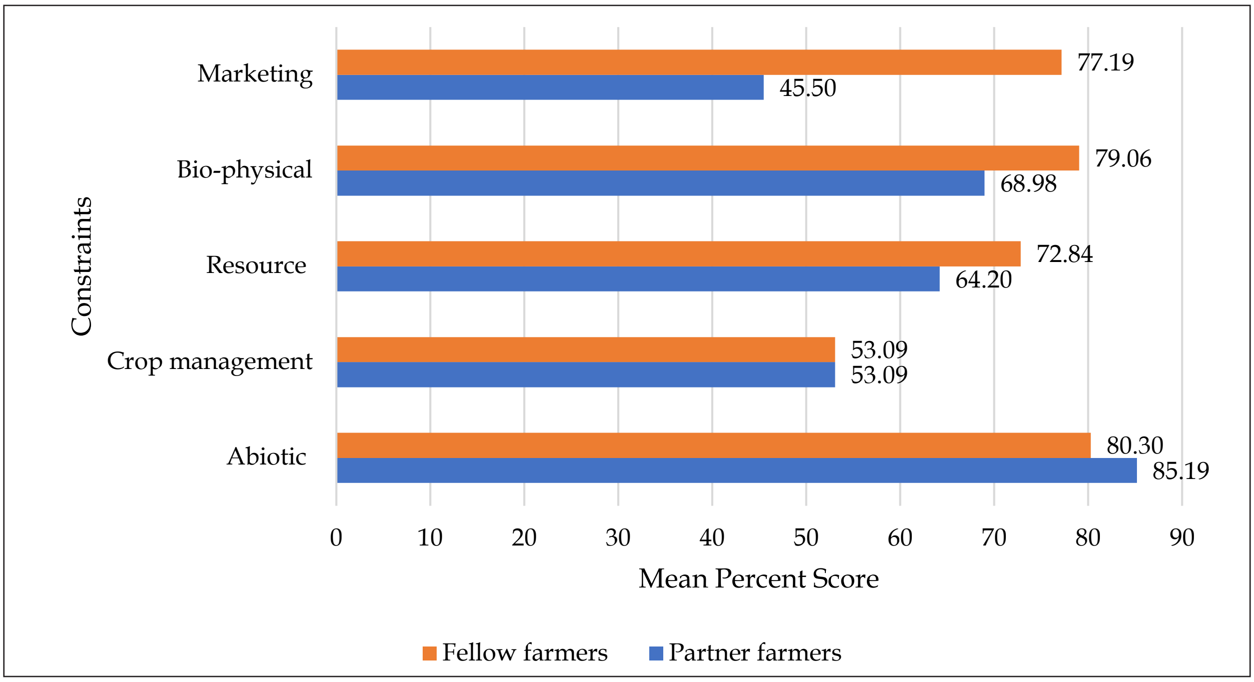

Fig. 1. Average value of constraints perceived by the partner and fellow farmers.

gaps in pulses. Pulse farmers often lack access to essential post-harvest infrastructure and inputs (FAO, 2019; Karthickraja *et al*., 2023). The imbalanced use of fertilizers and lack of soil testing further exacerbate soil health issues and sustainability concerns. Strengthening the supply chain of inputs, establishing community storage units, and providing soil testing and advisory services are necessary interventions (Singh *et al*., 2024).

Marketing constraints: Marketing is one of the most important aspects of the pulses industry. Marketing constraints arise due to weak market linkages, price volatility, and the absence of organised procurement systems, which leave farmers dependent on local traders. The dominant marketing issue was transportation costs, with the highest MPS. The other constraints were a lack of regulated markets and the absence of a minimum support price. Fellow farmers, in particular, were vulnerable to exploitation by intermediaries, price fluctuations, and collusion among traders. These findings align with previous studies, which have demonstrated that poor market linkages and information asymmetry result in suppressed farm-gate prices (Chand *et al*., 2015; Reddy *et al*., 2022). Establishing farmers' producers' organisations (FPOs), procurement centres, and conducting awareness drives on minimum support price (MSP) and quality standards can enhance market power for smallholder farmers (GoI, 2020; SFAC, 2022).

Table 2 presents the correlation between farmers' profiles and their constraints. Four variables, education, annual income, landholding, and social participation, show statistically significant negative associations. These negative correlations indicate that the severity of the constraints decreases as the levels of these variables increase. Farmers who are more educated perceive fewer constraints due to better access to information, awareness of improved practices, and the ability to adapt. Education enhances farmers' problem-solving capacity, technology adoption, and ability to access institutional support (Asfaw *et al*., 2012). Hence, agricultural education initiatives, particularly for adults and marginal farmers, need to be strengthened. Farmers with higher incomes experience fewer constraints. Since they can afford better inputs, hire labor, and access services. Higher income levels are

Table 2. Association between fellow farmers' profiles with constraints (n_2=81)

Personal profile	"r" value
Age	-0.046
Education	-0.255*
Family size	0.015
Family type	0.143
Caste	-0.155
Occupation	-0.165
Farming experience	-0.135
Annual income	-0.235*
Land holding	-0.359**
Mass media exposure	-0.113
Extension contacts	0.035
Social participation	-0.264*
Training obtained	0.014

*Significant @ 5%, **Significant @ 1%

associated with improved resilience to farming challenges (FAO, 2019; Reddy *et al*., 2022). Hence, it promotes diversification of income sources, off-season employment, and linkage to government support schemes, such as PM-KISAN and interest subvention on agricultural credit.

Larger landholders experience significantly fewer constraints, potentially due to better access to resources, economies of scale in inputs, and greater bargaining power in the market. Smallholders face additional constraints due to fragmented land ownership, low mechanization, and limited access to credit. Therefore, landless and marginal farmers can be supported through collective farming models, custom hiring centres, and shared input procurement. Farmers with higher social participation encounter fewer constraints. This is due to the peer learning, collective action, and institutional support. Social capital enhances the uptake of technology and risk management in farming (Pretty and Ward, 2001). Hence, encourage the formation and strengthening of FPOs and other rural institutions to enhance networking and resource sharing.

Conclusions

It has been observed that pulse cultivation in arid regions is primarily challenged by abiotic stresses, including a lack of irrigation, extreme temperatures, and poor soil conditions. These constraints hinder crop establishment and productivity, particularly for partner farmers operating in harsher environments. The findings emphasize the need for targeted interventions to address critical resource constraints, specifically improving irrigation infrastructure, enhancing soil health, and adopting climate-resilient practices. Moreover, disparities between partners and fellow farmers advocate the importance of strengthening institutional support, extension services, and farmer-to-farmer knowledge exchange. Coordinated action among stakeholders, including government bodies, research institutions, and farmer organizations, will be crucial for effectively addressing these challenges and ensuring sustainable improvements in pulse production. Regular appraisals and flexible strategies will be vital to adapting to changing field realities and maximizing impact. Promoting capacity building, economic empowerment, land access, and community engagement are crucial in reducing perceived farming constraints.

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