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Challenges encountered by maize growers in northern plains of India

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Abstract

The present study was conducted during 2022-23 in Punjab and the Jammu region of Jammu and Kashmir (UT). Two districts were chosen from Punjab: Ropar and Hoshiarpur and Jammu and from Jammu and Kashmir (UT): Jammu and Rajouri. Within these districts, three blocks with the maximum area under maize were purposively selected namely: Bhunga, Hoshiarpur-I, Hoshiarpur-II, Anandpur Sahib, Nupur Bedi and Ropar from Punjab and Akhnoor, Bhalwal Brahmna, Nagrota, Sunder Bani, Kalakote and Nowshera from sub-tropics of Jammu region. From each block, two villages were randomly selected, resulting in a total of 24 villages. Subsequently, 15 farmers were randomly selected from each village, yielding a final sample size of 360 respondents. The results of binary logistic model on factors affecting limitations faced by maize growers in cultivation of maize crop revealed that the major problems faced by the respondents were water scarcity which had the most significant impact on maize cultivation (54%) followed by labour shortage during peak time (41%), high fuel cost of transportation (36%), insect-pest attack (24%), power shortage (23%), wild animal menace (15%) and low market price (15%). In contrast, late availability of inputs (3%), poor quality inputs (7%) and absence of fixed price (30%) were not influenced by farmer-level factors indicating these are institutional issues. The findings suggest that improving maize cultivation requires both farm-level solutions such as better irrigation, pest management, mechanization and labour-saving practices along with institutional support for timely input supply, assured quality and fair price systems to make production more sustainable and profitable.

Keywords: Maize, low price, wild animal menace, impact, significant

Introduction

Maize (*Zea mays* L.) belongs to family Gramineae constitutes one of the chiefly grown food grains in the world. It is staple food for a large number of people in Latin America, Africa and Asia and is the basis for food security as per Consultative Group on International Agricultural Research (Erenstein *et al.*, 2022) [16]. Maize production has increased mainly because of its relatively better adaptation to different environments and strong demand for biofuel (ethanol) animal feed for the production of sweetening agents and other non-food industrial products, i.e., packaging materials that are biodegradable (Saldivar *et al.*, 2016) [17]. It is commonly called the "Queen of Cereals" and the "Miracle crop". It is one of the most versatile cereal crops which can be grown in various seasons (Dass *et al.*, 2012) [18]. It thrives in loamy sand to clay loam soils, but excessive or insufficient rainfall harms yield and quality. It is divided into two categories based on flavour and colour: yellow and white. Yellow maize is traditionally used for animal feed. It comprises most of the maize produced globally and is grown chiefly in northern hemisphere. White maize is generally considered a food crop that requires more favorable climatic conditions (Abbassian, 2006) [19]. Therefore, it is produced only in limited countries. Based on the size and composition of the endosperm, several hybrids of maize exist, *viz.* dent corn, flint corn, sweet corn, popcorn, baby corn, etc (Sandhu, *et al.*, 2004) [20]. Global maize production has surged in the past few decades, propelled by rising demand and a combination of technological advances. Currently, nearly 1147.7 million tonnes (MT) of maize is being produced together by over 170 countries from an area of 201 million hectare (Mha) with average productivity of 57.55 q/ha (Shekhar and Singh, 2021) [12]. In Indian agriculture, maize occupies a prominent position and each part of the maize plant is put to one or the other use and nothing of it goes as waste. Among the maize growing countries, India ranks 4th in area and 7th in production, representing around four per cent of the world maize area and two per cent of total production (FICCI, 2023) [4]. In 1950-51, India used to produce 1.73 MT of maize, which has increased to 31.5 MT by 2020-21. In India, Madhya Pradesh leads in maize production by having 6.57 MT followed by Karnataka having 5.42 MT and Maharashtra 4.26 MT (India Data Map, 2025) [6]. In Jammu and Kashmir (UT) maize is one of the major field crop cultivated in almost all districts covering an area of 2,89,179 ha with a production of 5,088,000 q/year (DES-J&K, 2021-22). It is the primary crop in the hilly districts of J&K and plays a crucial role in local livelihoods. Maize cultivation is prevalent across almost all districts in the Jammu region, with the highest area in Jammu (20.976 thousand hectares) followed by Rajouri (19.820 thousand hectares), Reasi (19.760 thousand hectares) and Udhampur (13.809 thousand hectares) districts (DES-J&K, 2021-22). Punjab is known as the "Granary of India". Maize in Punjab is cultivated on an area of 105.2 thousand hectares and production of 395 thousand tonnes (Statistical Abstract of Punjab, 2021-22). In Punjab, maize crop is mainly sown in the districts of Hoshiarpur, Roopnagar, Shaheed Bhagat Singh Nagar, Amritsar, Gurdaspur, Jalandhar, Kapurthala, Patiala, Ludhiana, SAS Nagar and Fatehgarh Sahib Districts. Despite having a leading edge in area and production of maize, J&K and Punjab do not appear among the top maize-producing states of India, as the maize growers of these regions face significant challenges in maize production namely water scarcity during peak periods, insect pest attacks, high fuel cost of transportation, wild animal menace and so on. Studies conducted across the world and India by different researchers have also reported diverse constraints in maize cultivation. For instance, Abdallah *et al.* (2024) [1] highlighted how topography and irrigation significantly influence water scarcity while Inbathamizha *et al.* (2023) [5] observed that marketing channels determine the extent of price realization. Labour shortages during peak seasons have been emphasized by Jha and Marahatta (2023) and Rajkhowa and Kubik (2021) [7], whereas pest-related challenges have been discussed in detail by Rajkhowa and Kubik (2021). Similarly, Joshi (2017) [8, 11] reported that tractor ownership though beneficial for mechanization increases vulnerability to fluctuating fuel costs. Institutional challenges such as delayed availability and poor quality of inputs were also highlighted in the results of Daum and Birner (2017). Meyer-Aurich *et al.* (2013) [2, 10] further emphasized that addressing such production risks requires integrating technological innovations with institutional reforms. On the basis of these differentiated results, it was decided to assess the challenges faced by maize growers of sub-tropics of Jammu region and Punjab.

Materials and Methods

The study was carried out in Punjab and the Jammu region of Jammu and Kashmir (UT). Two districts each were chosen from Punjab state: Ropar and Hoshiarpur and from Jammu and Kashmir: Jammu and Rajouri. From the selected districts, three blocks with the maximum area under maize were selected namely: Bhunga, Hoshiarpur-I, Hoshiarpur-II, Anandpur Sahib, Nupur Bedi and Ropar from Punjab and Akhnoor, Bhalwal Brahmna, Nagrota, Sunder Bani, Kalakote and Nowshera from Jammu. From each block, two villages were randomly selected, resulting in a total of 24 villages. Subsequently, 15 farmers were randomly selected from each village, yielding a final sample size of 360 respondents. Data collection was undertaken through semi-structured interviews conducted at farmers' homes, fields, or community centers. To ensure clarity and consistency of the interview schedule pre-tested was conducted before the survey. The collected data were later analyzed using SPSS software.

Table 1: Sampling plan

S.No.	Name of the State/ UT	Total no. of districts Selected	Total no. of blocks selected	Total no. of villages selected	Number of maize growers selected randomly from each village	Total no. of respondents selected
1.	J&K	02	06	12	15	180
2.	Punjab	02	06	12	15	180
Total		04	12	24	15	360

Statistical tools applied

Percentage: The frequency of a specific cell was determined by dividing it by the total number of respondents in that category and then multiplying the result by 100.

$$\text{Percentage} = \frac{\text{Actual Number of Respondents}}{\text{Total Number of Respondents or Score}} \times 100$$

Frequency

The calculation involved summing up the total number of respondents within each specific category.

Arithmetic mean

It was calculated to the average value of particular score by applying the formula given below:-

$$\text{Average Score} = \frac{\text{Total Scores on a Particular Item}}{\text{Number of Respondents}}$$

Binary Logistic Regression Model: Binary logistic regression model was applied identify the independent variables influencing the dependent variable. The result of this type of regression can be expressed as follows:

Ln [p/1-p]=b0+b1x1+b2x2+b3x3………bkxk

Where;

- p represents the probability of an event
- b_0 is the y - intercept, and
- $x_1$tox_k represents the independent variables included in the model.

For the validation of model, chi square test was taken into account. The Nagelkerke's R2 was used as measure of determination of variation caused by predictors. This model was used to identify the major constraints affecting maize production and the results are presented in Table 3. Ten critical production and marketing constraints were considered as dependent variables: water scarcity (Y_1), late availability of inputs (Y_2), low price for maize (Y_3), damage from wild animals (Y_4), shortage of electricity (Y_5), pest infestation (Y_6), high transportation cost due to fuel (Y_7), shortage of labour during peak operations (Y_8), absence of a fixed selling price (Y_9) and poor quality of inputs provided by government agencies (Y_{10}). The explanatory variables used in the model included education (X_1), size of operational holding (X_2), topography (X_3), location (X_4), area under maize (X_5), irrigation facility (X_6), marketing channel (X_7), grain yield (X_8), thinning practice (X_9), method of sowing (X_{10}), use of hired labour (X_{11}) and source of information (X_{12}).

Results and Discussion

The result presented in Table 2 revealed that average age of respondents from Jammu was 54 ± 0.95 years, while the average age of respondents from Punjab was 49 ± 0.92 years. A significant difference at 1 per cent level of significance was observed between the average age of respondents in the two regions. The average number of formal schooling was 08 years for Jammu respondents and 09 years for Punjab respondents and was statistically significant at 1 per cent level of significance between Jammu and Punjab respondents with difference value of 01 year. Majority of the respondents Jammu (97%) and Punjab (99%) of had phone connection availability out of these, 62 and 84 per cent of Jammu and Punjab respondents, respectively possessed smart phones. The results further highlights that Jammu respondents were having more experience in farming (37.93 years) compared to Punjab farmers(32.34 years) and the difference was statistically significant at 1 per cent level of significance with a difference value of 5.59 years. Subsequently, the average family size of Jammu and Punjab respondents was 05 members each and majority of the respondents from both the regions had nuclear family type.

Table 2: Socio personnel profile of respondents

Parameters	Jammu (n=180)	Punjab (n=180)	ǀ Difference ǀ	Test (p-value)
Mean age (years)	54 ± 0.95	49 ± 0.92	05	t=3.61** (p<0.01)
Mean education (formal number of schooling years completed)	08 ± 0.25	09 ± 0.20	01	t=5.02** (p<0.01)
Phone Connectivity				
Phone connection availability	97	99	02	Z=0.211 NS (p>0.05)
Smart Phone	62	84	22	Z=2.36* (p<0.05)
Feature phone	35	15	20	Z=3.04** (p<0.01)
Farming Experience of respondents				
Average farming experience (year)	38.18 ± 0.94	32.85 ± 0.90	5.33	t=4.07** (p<0.01)
Average maize cultivation experience (year)	37.93 ± 0.96	32.34 ± 0.92	5.59	t=4.19** (p<0.01)
Family type				
Average family size (no.)	5 ± 0.17	5 ± 0.16	-	t=1.083 NS (p>0.05)
Nuclear family	78	86	08	Z=0.84 NS (p>0.05)
Joint family	22	14	08	Z=1.40 NS (p>0.05)

± Std error mean,** Significant at p<0.01,* Significant at p<0.05, NS= Not Significant

Figures in parentheses are standard mean error and figures corresponding to percentages have been rounded off to the nearest whole number.

The results of Table 4.32 indicates that 77 per cent of respondents in Jammu identified wild animal menace as the primary constraint, followed by water scarcity 72 per cent, late availability of inputs 46 per cent, poor quality of inputs supplied by the agriculture department 40 per cent and high insect-pest infestation 39per cent. In contrast, 76 per cent of respondents in Punjab highlighted severe insect-pest infestation as the major constraint, with other issues including wild animal menace 57 per cent, late input availability 42 per cent, low market price for maize produce 41 per cent, power shortages 40 per cent and labour scarcity during peak periods 39 per cent.

Table 3: Constraints reported by maize growers

Parameter #	Jammu (n=180)	Punjab (n=180)	ǀ Difference ǀ	Test (p-value)
Water scarcity	72	09	63	Z=7.95** (p<0.01)
Late availability of inputs	46	42	04	Z=0.49NS (p>0.05)
Low rate for the maize produce	20	41	21	Z=2.95* (p<0.05)
Wild animal menace	77	57	20	Z=2.18** (p<0.05)
Power shortage	03	40	37	Z=6.01** (p<0.01)
High infestation of insect-pest	39	76	37	Z=4.18** (p<0.01)
High fuel cost for transportation of maize produce	-	02	02	-
Labour shortage during the peak time	-	39	39	-
No fixed rate for the maize produce	-	02	02	-
The inputs provided by agriculture department are not of good quality	40	22	18	Z=2.51NS (p<0.05)

** Significant at p<0.01, * Significant at p<0.05, NS= Not Significant, # Multiple response.

Figures are percentages and rounded off to the nearest whole number.

Determinants of Constraints in Maize Cultivation (Binary Logistic Regression): The results revealed that the nature and severity of constraints varied considerably among farmers depending on their resources, practices and location. For water scarcity, both topography (p<0.01) and irrigation status (p<0.05) were significant. The model explained 54 per cent of the variation indicating that farmers located in difficult terrains and those without assured irrigation were most vulnerable to water shortages. With respect to low maize prices, marketing channel (p<0.05) was significant. About 15 per cent of the variation was explained by the model implying that reliance on less competitive channels leads farmers to fetch lower price. In the case of wild animal menace, topography (p<0.01) and thinning practice ($p<0.05$) were significant. The explanatory power was modest ($R^2 = 0.146$) but it indicates that farms located in vulnerable landscapes and those not following proper thinning are more prone to wild animal damage. For power shortage, irrigation source ($p<0.01$) was the major factor with the model accounting for 23 per cent of the variation. Farmers using electricity-based irrigation systems experienced more severe disruptions from power cuts. Regarding pest infestation, four factors were significant namely location ($p<0.01$), maize area ($p<0.05$), method of sowing ($p<0.05$) and landholding size ($p<0.01$). The model explained 24 per cent variation showing that larger maize areas, certain sowing practices and specific locations were more pest-prone while larger holdings slightly reduced vulnerability. For high fuel cost of transportation, tractor ownership ($p<0.05$) was significant. The model explained 36 per cent variation suggesting that, although tractors improve efficiency but at same time they also increase exposure to fuel cost fluctuations. In the case of labour shortage during peak seasons, hired labour for sowing ($p<0.01$), hired labour for harvesting ($p<0.01$) and maize yield ($p<0.05$) were significantly affecting the maize cultivation. The model explained 41 per cent variation indicating that higher yield farms and those heavily dependent on hired labour experience greater labour scarcity.

Table 4: Factors affecting the limitations faced by the maize growers in the cultivation of maize (Binary Logistic Regression)

Dependent variables	Independent variables	Coefficient B	S.E.	Wald	Df	p-value	Model summary
Water scarcity	Constant	1.940	.317	37.503	1	.000**	Nagelkerke R Square =.541 -2 Log likelihood=301.882 X^2= 184.262
	Topography	-2.350	.349	45.319	1	.000**	
	Irrigated/Un-irrigated	-2.629	1.122	5.489	1	.019*	
Low rate for maize produce	Constant	-42.568	2.388E4	.000	1	.999	Nagelkerke R Square =.146 -2Log likelihood=402.357 X^2=39.147
	Marketing channel	1.075	.428	6.292	1	.012*	
Wild animal menace	Constant	.724	1.263	.328	1	.567	Nagelkerke R Square =.146 -2 Log likelihood=418.382 X^2=39.909
	Topography	2.107	.550	14.678	1	.000**	
	Thinning practice	-.188	1.250	.023	1	.023*	
Power shortage	Constant	-2.560	.304	71.156	1	.000**	Nagelkerke R Square =.229 -2 Log likelihood=313.617 X^2=57.489
	Location	.212	.284	.557	1	.456	
	Source of irrigation	1.539	.489	9.917	1	.002**	
High infestation of insect-pest	Constant	-3.486	1.655	4.434	1	0.35	Nagelkerke R Square =.241 -2 Log likelihood=419.00 X^2=71.279
	Location	.661	.247	7.712	1	.007**	
	Area under maize	.719	.294	5.968	1	.015*	
	Sowing method	2.715	1.220	4.951	1	.026*	
	Operational land holding	-.199	.075	7.123	1	.008*	
High fuel cost for transportation	Constant	-38.601	6.169E3	.000	1	.995	Nagelkerke R Square =.362 -2 Log likelihood=28.658 X^2=15.295
	Tractor possession	3.372	1.403	5.775	1	.016*	
Labour shortage during peak season	Constant	-38.368	5.951E3	.000	1	.995	Nagelkerke R Square =.411 -2 Log likelihood=247.326 X^2=107.349
	Hired labour (sowing)	-1.491	.346	18.518	1	.000**	
	Hired labour (harvesting)	1.258	.339	13.753	1	.000**	
	Maize grain yield	.022	.009	6.616	1	.010*	

**Significant at <0.01,*Significant at $p<0.05$ per cent.

Discussion: The study revealed that maize farmers face multiple constraints which vary with their resources, practices and location. Water scarcity was found to be more severe in difficult terrains and in farms without assured irrigation, indicating the need for location-specific water management practices and promotion of micro-irrigation systems. This is in line with the findings of Abdallah *et al.* (2024) [1]. Farmers relying on non-competitive marketing channels received lower returns for maize suggesting that strengthening regulated markets and farmer cooperatives can improve price realization which supports the results of Inbathamizha *et al.* (2023) [5]. Further, ecological problems such as wild animal menace and pest infestation were also prominent. Farmers in vulnerable landscapes and those not following proper thinning practices were more prone to wild animal damage, while pest incidence was influenced by sowing methods, maize area and landholding size. These findings emphasize the importance of community-based crop protection measures and adoption of site-specific integrated pest management practices. Similar findings was reported by Rajkhowa and Kubik (2021) [11]. Power shortages were critical for farmers dependent on electricity-based irrigation, while tractor-owning farmers were more vulnerable to rising fuel costs, a trend also noted by Joshi (2017) [8]. Labour scarcity was particularly acute in high-yield farms dependent on hired labour during sowing and harvesting, which is in conformity with the findings of Jha and Marahatta (2023) and Rajkhowa and Kubik (2021) [7, 11]. The findings point towards the importance of encouraging farm mechanization, cooperative labour arrangements and renewable energy-based irrigation to minimize farmers' risks. More importantly, extension programmes should not only promote new technologies but also provide strong institutional support. Further, by focusing on water management, pest control, market access, energy use and labour availability extension agencies can help farmers address production challenges more effectively and improve maize productivity. Similar observations were also reported by Daum and Birner (2017) and Meyer-Aurich *et al.* (2013) [2, 10].

Conclusion
The analysis depicted that maize farmers face several key constraints with varying levels of influence explained by the regression models. Water scarcity was strongly affected by topography and irrigation status accounting for about 54 per cent of the variation while wild animal menace was influenced by topography and thinning practices explaining around 15 per cent. The problem of low prices for maize was linked to marketing channels with about 15 per cent variation explained and power shortage was associated with irrigation sources explaining 23 per cent variation. Pest infestation was more common in certain areas on larger maize plots and under particular sowing methods together explaining about 24 per cent of variation. High fuel costs were linked to tractor ownership accounting for 36 per cent of the variation while labour shortage during sowing and harvesting was mainly due to reliance on hired labours and higher yields explaining about 41 per cent of variation. In contrast, late input supply (3%), poor quality of inputs (7%) and absence of fixed produce prices (30%) were not explained by farmer-level factors pointing to weaknesses in the input and market systems. Moreover, the findings suggest that maize farming can be strengthened through a mix of farm-level improvements such as irrigation facilities, pest-specific control methods, fuel-efficient machines and labour-saving practices along with institutional support in the form of reliable input delivery, better quality assurance and fair and transparent pricing.

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