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PROFITABILITY AND RESOURCE USE EFFICIENCY OF MUSTARD FARMING IN KURIGRAM DISTRICT OF BANGLADESH

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ABSTRACT

Mustard is the most widely grown oilseed crop and plays a vital role in meeting the demand for edible oil in Bangladesh. This study was conducted in five mustard-growing areas of Nageswari upazila of Bangladesh, to estimate the socio-economic characteristics of the mustard farmers and the profitability and potentiality of mustard production. Tabular, descriptive, econometric and Cobb-Douglas (C-D) production models were used to fulfill the objectives. This study found that mustard production is less profitable with a benefit-cost ratio of only 1.02 and human labor (0.093), machinery (0.002) and seed (0.024) had a significant positive role in yield whereas irrigation (0.006) had a significant negative role. Farmers face challenges such as limited access to credit, low-quality inputs, insufficient government support and pest and disease issues. Addressing these constraints through improved access to quality seeds and modern farming technologies could enhance mustard productivity and reduce the dependence on imported edible oil. This study provides valuable insights for policymakers and researchers to promote sustainable mustard production in northern Bangladesh.

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I. INTRODUCTION

A crop with a short lifespan is mustard which is primarily grown in the winter. It is sown in mid-October to mid-November and harvested in late January or early February. It has 20–25% protein and 40–45% oil. In addition to having a high caloric content, mustard is also a good source of fat-soluble vitamins, including A, D, E and K. Worldwide, mustard is a significant oilseed. With an average share of 28% of global output, Canada leads the world's mustard seed crop production (Sultana et al., 2020). In Bangladesh, mustard is the most common oilseed crop having the largest output among oilseeds. In 2022, Bangladesh was used 330,700 hectares of land for producing mustard (BBS, 2022). Approximately 0.36 million tons of edible oil are produced annually in the nation, compared to 1.4 million tons that are needed (Mallik, 2013). Mustard is not cultivated in sufficient quantity in Bangladesh as per the requirement (BBS, 2016; Bokhtiar et al., 2023; Mallik, 2013). Increasing the production of mustard may be one of the ways to minimize the demand-supply gap of edible oil in the country but production is not increasing at the rate at which human demand is increasing. Therefore, mustard oil has to be imported from abroad every year (Sultana et al., 2020). According to Bangladesh Bank, the values of imported oilseeds and edible oils were Tk 14,200 million and Tk 130,510 million in 2012, which were 285 % and 519 % higher compared to the values of 2003 (Miah et al., 2015). Because of this, the government must import mustard each year, which hurts the economy. In order to reduce the import of mustard oil, the country needs to increase the production of mustard and motivate farmers to increase mustard production. Therefore, it is necessary to determine the profitability of mustard; this will assist policymakers in developing a new policy to boost mustard production.

Several studies have evaluated the financial viability of mustard cultivation in Bangladesh and other regions. Arif et al. (2019) found mustard farming to be profitable in the Manikganj district with a net return of Tk. 45,972/ha and a BCR of 2:1. Begum et al. (2011) assessed the benefit-cost ratios of various crops underscoring the economic potential of mustard compared to alternatives such as maize and groundnut. Sultana et al. (2020) highlighted that factors like education, income, and farming experience could enhance mustard farming efficiency, while access to quality seeds remained a key constraint. Shah et al. (2021) analysed farm size variations, finding that larger farms had higher gross profits and lower production costs per unit compared to smaller farms. In contrast, Rabbani et al. (2013) emphasized the need for managerial and technological training to optimize input use and enhance farm income. Uddin et al. (2024) identified major drivers of mustard adoption, including consumer preferences, product pricing, extension services, and household labor availability. Miah et al. (2015) found that only 40% of farmers adopted improved mustard varieties but 53% expressed interest in expanding their cultivation area. These studies underscore the potential for increasing mustard yields and profits through enhanced variety adoption, yet challenges such as seed availability and farmer awareness remain underexplored. Recent findings by Uddin et al. (2024) emphasized the need for improved institutional credit facilities, input subsidies and market access to enhance mustard production. Despite these recommendations, little research has focused on the specific policy constraints faced by mustard farmers in Bangladesh. Although numerous studies have examined mustard production, profitability and adoption patterns, there remains a significant gap in financial analyses of Bangladesh with focusing an essential mustard-producing region.

To ensure that. Kurigram district was selected randomly from among the mustard-producing districts of Bangladesh. This study aims to fill these gaps by providing an in-depth financial analysis of mustard cultivation in northern part of Bangladesh, with a focus on production costs, returns, factors influencing profitability and potentiality. Therefore, this study was designed to fill this gap by addressing the following objectives: to analyze the characteristics of mustard farmers in the study area, to estimate the financial profitability of mustard, to identify the factors affecting the production of mustard and to determine the potential and problems associated with the production of mustard and its possible solutions.

II. MATERIALS AND METHODS

2.1 Selection of the study area and sample size determination

To get data and achieve the objectives of this study, multi-stage simple random sampling was used in this study. Initially, the Kurigram district was selected randomly from out of the mustard-producing districts in Bangladesh. Secondly, Nageswari Upazila was randomly selected from nine upazila in the Kurigram district. Ultimately, out of the fourteen unions and one municipality in Nageswari Upazila, four unions and one municipality were selected at random. The researcher collected data during the month of March to April 2024 through personal interviews. While the actual number of farmers differed within each union, equal sample numbers were taken by increasing the overall sample size. This was done for the purpose of ensuring an equal amount of representation and a valid way to compare the unions on their relative merits while avoiding bias due to differing distribution of the sample size among unions. The basic information about the mustard-producing farmer was provided by Upazila Agriculture Extension Officer (UAEO). Secondary data were gathered from BBS, books, journals, articles, the internet and Bangladesh Economic Review. The study used a simplified formula to determine the sample size. The formula is $n = \frac{N}{1+N(e^2)}$ Where 'n' is the required sample size, 'N' is the total population, and 'e' Is the level of precision, sometimes called sampling error (0.05). The total number of mustard-producing farmers during the cultivating year 2023-24 was 31037 (UAEO, 2024). The researcher found that the total sample size $= \frac{31037}{1+31037\,(0.09^2)}$ $=122.97$ or $123.$ To find a good result, the researcher in this study covered almost 250 mustard farmers out of four unions and one municipality.

2.2 Analytical Technique

The two most common concepts that are unavoidable in economic analysis are cost and return. To determine the feasibility of the planned enterprise, a farm must compute profit. Total cost (TC) is the sum of total variable costs and fixed costs. All the calculations in this study had been completed based on per acre. The most common method of determining and comparing the profitability of the farm is a cost and benefit analysis (Sampa *et al.*, 2020; Kiron & Islam, 2023). One simple formula is used to estimate the level of profitability of crop production.

$$\pi = P_1Q_1 + P_2Q_2 - \sum(W_i\,X_i) - TFC \;\ldots\; (1)$$

Here, π = Profit per acre for producing the crop, P_1= Per unit price of output, Q_1= Quantity of output obtained, P_2= per unit price of by-product (Tk), Q_2= Quantity of by-products obtained, W= Price of input used for producing the crop, X= Quantity of input used in producing the crop, TFC= Total fixed cost (Tk). The cost of land usage was taken into consideration as a fixed cost and was computed as an opportunity cost (IOC) based on the amount of land used per acre throughout the four-month cropping period. For mustard, interest on working capital for four months was calculated at a rate of 12 % annually. The following formula was used to determine interest on operating capital: Interest on working capital (IOC) = Alit, Al = Total investment in production/3, I = Interest rate, which was 12% per year during the study period, t = Timeline of a cycle. The equation for Cost analysis is as follows: Variable cost, VC = $\sum(X_i W_i)$, TVC= VC+IOC, TC= TVC+TFC Where; TC = Total cost (Tk/acre), TVC = Total variable cost (Tk/acre), TFC = Total fixed cost (Tk/acre), IOC = Interest of operating capital (Tk/acre), X = Quantity of inputs (kg), W = Price of inputs (Tk/kg), VC = Variable cost (Tk/acre). The following formulas were used to determine the gross return per acre, gross margin, and net return or profit: The equation for profitability as Gross Return, GR= YP Where; P = Price (Tk/kg) received by farmers, Net Return, NR= GR−TC, Gross Margin, GM= GR−VC, , Y = Quantity (kg/acre) produced, BCR = Gross Return/Total Cost. To estimate the production function and identify the variables influencing mustard production in the chosen district, the Cobb-Douglas regression model was employed. The following kind of Cobb-Douglas production function was employed in the study to gauge the contribution of the most crucial factors in the mustard production process.

$$Y = AX_1^{b_1} X_2^{b_2} \ldots\ldots\ldots X_n^{b_n} eu \ldots (2)$$

For using the OLS, the Cobb-Douglas production function converted into log form from exponential form, i.e.,

$$ln\, Y = ln\, a + b_1 ln\, X_1 + \ldots. + b_n\, lnX_n + Ui \ \ldots (3)$$

The empirical production function was as follows:

$$ln\, Y = ln\, a + b_1 ln\, X_1 + b_2 ln\, X_2 + b_3 ln\, X_3 + b_4 ln\, X_4 + b_5 ln\, X_5 + U_i \ldots (4)$$

Where, Y = Yield (kg/acre), X_1 = Human labor cost (TK/acre), X_2 = Machinery (Tk./acre), X_3 = Irrigation (Tk./acre), X_4 = Seed (kg/acre), X_5 = Fertilizer (kg/acre), a = Intercept, U_i = Error term and $b_1, b_2, \ldots b_n$ be the Coefficients of the respective variables to be estimated. The Cobb-Douglas production function, sometimes referred to as the trans-log functional form, served as the foundation for a large portion of research on agricultural production analysis. As a result, this study conducts the hypothesis test. The computed LR statistics for the hypothesis was less than the Table value at the 5% level of significance (LR statistics 47.116 < 67.505). As a result, the null hypothesis—that the data is better represented by the C-D production functional form—was accepted. Consequently, the C-D production function was utilized. SWOT analysis is a tool used to assess the strengths, weaknesses, opportunities, and threats of an enterprise. It helps identify the strengths (strong brand, skilled workers), weaknesses (resource scarcity, operational inefficiencies), opportunities (new market trends, competitor weaknesses) and threats (economic downturns, new competition, or technological shifts). By examining these components, policy makers can develop strategies to leverage strengths, address weaknesses, capitalize on opportunities and mitigate threats (Uddin *et al.*, 2024).

III. RESULTS AND DISCUSSION

3.1 Characteristics of the mustard farmers

The socioeconomic status of farmers has a significant impact on production planning. The age of mustard producers plays an important role in the decision of mustard-producing activities. The highest number of mustard farmers belong to the old age (43%) group. About 24% of mustard farmers can write their names, 35.6% have a secondary education and approximately 2% have completed post-graduation. Most of the respondent families belonged to the medium-sized family

(5-8) category while only about 3% of the respondents belonged to the large family size category. There were four categories of land ownership patterns, mortgage in, contact in or rented, leased in or sharecropping, and single ownership of mustard-producing land, found in the study area. In mustard farming, about 58.8% respondents were single landowners, 27.2% respondents were mortgage owners, 10% respondents were contacted by the owner and later, 4% were sharecroppers. About 97% of the sample farmers didn't take any training and 3% took training on mustard cultivation. Formal (Bank, organization) and informal (Money lenders, relatives) are two sources of agricultural credit. Only 17% of the mustard farmers were taken credit facilities in their emergence situations. Extension contracts are important to study because it has a significant role in mustard production.

Table 1: Socio economic characteristics of the farmers

Socioeconomic Variables	Category	Frequency	Percentage
Age of farmers (years)	Young (20–35)	78	31.20
	Middle-aged (36–45)	65	26.00
	Old (46 and above)	107	42.80
Educational status	Can write name only	61	24.40
	Primary education	43	17.20
	Secondary education	89	35.60
	Higher Secondary (HSC)	21	8.40
	Graduate	32	12.80
	Postgraduate	4	1.60
Family size (members)	Small (1–4)	83	33.20
	Medium (5–8)	160	64.00
	Large (9 and above)	7	2.80
Land ownership pattern	Single ownership	147	58.80
	Mortgaged-in	68	27.20
	Rented/contract	25	10.00
	Sharecropping	10	4.00
Training received	Yes	8	3.20
	No	242	96.80
Credit facility	Received	43	17.20
	Not received	207	82.80
Extension contact	Yes	80	32.00
	No	170	68.00

About 32% of the farmers had received advice about mustard production procedures from the extension officer. The production input utilization and production related characteristics of the farmers are presented in the table 2. In the study area, the highest source of mustard seed and irrigation were 27.2 % and 52 % from BADC and electric pump respectfully. A variety of mustard has a significant role in mustard production. The survey result showed that 37.6% of the farmers used BARI-14 mustard seed for mustard production.

Table 2: Production, Input Use and Knowledge-related Characteristics

Variables	Category	Frequency	Percentage
Source of seed	BADC	68	27.20
	Company	55	22.00
	Own seed	49	19.60
	Local market	45	18.00
	Neighbor	26	10.40
	Others	7	2.80
Source of irrigation	Electric pump	130	52.00
	Shallow tube well	58	23.20
	Deep tube well	35	14.00
	Others (pond/river/lake)	27	10.80
Variety of mustard seed	BARI-14	94	37.60
	Local (Kajli)	73	29.20
	BARI-17	15	6.00
	BARI-18	14	5.60
	Others	54	21.60
Knowledge of soil pH	Known	6	2.40
	Unknown	244	97.60

It is so important to know the P^H value of the land to apply fertilizer. However, this study found that only 2 % of the mustard-producing farmers knew about the P^H value of their land. Neighbour farmer inspiration is the main reason for mustard production (Table 3).

Table 3: Reasons for cultivating mustard

Reason for cultivating	Frequency	Position
Inspired by a neighbour farmer	196	1
Less disease	86	5
Low cost and maintenance	109	3
High yield	70	6
Short term	177	2
Low irrigation cost	95	4
Others	61	7

Short-duration crop, low cost and maintenance, low irrigation cost, less disease and high yield having the position of second, third, and so forth respectively.

3.2 Profitability of mustard cultivation

The vital variable input in the production process is the human labor. For implementing various activities and management such as land preparation, harvesting, etc., human labor is needed. Human labor may be hired labor or family labor. The cost of human labor was computed based on the wage rate per 8-hour day with a person for hired labor and the opportunity cost concept for family labor (based on the hired labor wage rate). Labor wage rate varies with respect to unions in different areas. So, to avoid complexity, this study used an average rate that varied from Tk 350 to Tk 500 per man-day. The following Table 4 shows the cost of the production. The average human labor cost per acre was Tk. 8395.96, which constituted 31.13% of the total cost.

Table 4: Per acre variable and fixed cost of mustard cultivation in financial perspectives

Variable	**Variable cost (Tk/acre)**	
	Financial cost	
	Tk	Percentage
Human labor	8395.96	31.13
Tillage	2550.00	9.46
Irrigation	750.00	2.78
Seed	330.00	1.22
Urea	1800.00	6.67
TSP	1500.00	5.56
MP	1470.00	5.45
Gypsum	660.00	2.44
Zinc sulphate	546.00	2.02
Boric acid	300.00	1.11
Manure	1050.00	3.89
Total fertilizer	7026.00	26.05
Pesticides/insecticides	285.00	1.06
Opportunity cost on capital	580.08	2.15
Total variable cost	19917.06	73.86
Fixed cost (Tk/acre)		
Land rent	7050.00	26.14
Total cost	26967.06	100.00

The per acre machinery cost for mustard was Tk. 2550 which constituted 9.46 % of the total cost. Irrigation is needed at the appropriate time for the proper growth of mustard. The average per acre irrigation cost was calculated as Tk. 750 which constituted 2.78 % of the total cost. There was variation in the price of seed from one union to another union from time to time. The average seed cost per acre was Tk. 330 which constituted 1.22% of the total cost. Fertilizers include both organic (cow dung) fertilizer and inorganic fertilizer. Inorganic fertilizers include urea, TSP, MP, gypsum, boric acid and zinc sulphate. The average market prices of major fertilizers were Tk. 25, 25, 18, 160, 70, 165 and 5 per kg for urea, triple super phosphate (TSP, muriate of potash (MP), boric acid, gypsum, zinc sulphate and manure respectively. On a per acre basis, the total expenditure on fertilizers accounted for 6.67 %, 5.56 %, 5.45 %, 2.44 %, 1.11 %, 2.02 % and 3.89 % of the total cost respectively. The average herbicide cost per acre of mustard cultivation was Tk. 285 which constituted 1.06 % of the total cost. Herbicides include both pesticides and insecticides. Interest in the working capital of mustard cultivation was estimated at Tk. 580.08 which constituted a 2. 15 % share of total cost. Farmers use the land in accordance with the terms of the contract or lease agreement. Leasing cost varies from one area to another area depending upon soil fertility, irrigation system, cropping pattern, etc. Based on the opportunity cost concept, rent for own land was measured. The rental value per acre was 7050 which was the total fixed cost. The gross return per acre mustard was calculated by multiplying the total amount of production by their market prices. The gross return was found to be Tk. 27281.02 per acre (Table 5).

Table 5: Gross margin and benefit-cost ratio of mustard cultivation

Gross Return (GR)		**Amount (Tk/acre)**
Yield (kg/acre)	Price/kg	25256.02
410.40	61.54	
By product (Tk/acre)		2025.00
Gross Return		27281.02
Items		Financial measure
Total variable cost (TVC)		19917.06
Total fixed cost (TFC)		7050.00
Total cost (TC); TFC+TVC		26817.06
Net return (NR)	Tk	463.96
	%	1.73
Gross margin (GM); GR-TVC	Tk	7363.96
	%	27.46
Benefit-cost Ratio (BCR); GR/TC		1.02
Comment		Financially benefited

The net return was estimated as Tk. 463.96 per acre indicates that mustard production is profitable for the study area. It was evident from the study that the benefit-cost ratio on the full cost basis of mustard cultivation was 1.02, implying that Tk. 1.02 would be earned by investing Tk. 1.00

for mustard production (Slightly above the finding of Sampa *et al.*, 2020). Therefore, mustard production was found profitable for farmers in the study area (Arif *et al.*, 2019; Rayhan *et al.*, 2013; Sarkar, 2021; Sultana *et al.*, 2024; Uddin *et al.*, 2024).

3.3 Factors affecting the yield of mustard cultivation

To examine the effects of different inputs on mustard yield, the Cobb–Douglas production function analysis was used to this study. Multicollinearity among the independent variables was assessed using both tolerance & variance inflation factor (VIF). The explanatory variables had VIFs of less than 10 and tolerance of more than 0.1 (Appendix 1); therefore, multicollinearity did not arise in the model. The estimated regression coefficients, levels of significance and overall model statistics are presented in Table 6. It is evident that the coefficient of human labor was positive and statistically significant at the 10 % level of significance indicates that a 1 % increase in human labor, keeping other factors constant, would increase mustard yield by 0.031 % (Similar with Islam *et al.,* 2024).

Table 6: Cobb-Douglas regression estimates for Mustard production

Variables	Co-efficient	Standard error	P-value
Constant	4.380	0.580	0.000***
Human labor	0.031	0.018	0.093*
Machinery	0.149	0.048	0.002***
Seed	0.162	0.072	0.024**
Irrigation	-0.055	0.020	0.006***
Fertilizer	0.009	0.022	0.681
R square		0.832	
Adjusted R square		0.826	
F value		186.450***	
Returns to scale		1.070	
Observations(n)		250	

*Note: ***, **, * indicates significant at 1%, 5% and 10% level of significance.*

The coefficient of machinery was also positive and highly significant at the 1 % level implying that a 1 % increase in machinery use would increase mustard yield by 0.149 % (this finding similar with the finding of Sarkar, 2021). The coefficient of seed was found to be positive and significant at the 5 % level, suggesting that a 1 % increase in seed use would increase mustard yield by 0.162 %. This result is consistent with earlier findings reported by Sarkar (2021) and Sultana *et al.* (2020). In contrast, irrigation showed a negative but statistically significant effect on mustard yield at the 1 % level. 1 % increase in irrigation application would decrease mustard yield by 0.055 % which may be attributed to inefficient or excessive irrigation practices (Hossain *et al.*, 2013; Sarkar, 2021). Furthermore, the coefficient of fertilizer was positive but statistically insignificant, indicating that fertilizer application had no significant effect on mustard yield. The estimated coefficient value of 0.009 suggests a negligible impact on production (Hasan *et al.*, 2023). The coefficient of determination (R^2) was estimated at 0.832, indicating that about 83 %

of the variation in mustard yield was explained by the explanatory variables included in the model. The overall goodness of fit of the model was confirmed by the F-statistic value of 186.450 which was significant at the 1 % level implying that the explanatory variables jointly exerted a significant influence on mustard yield. Finally, the sum of the estimated production coefficients was 1.070, indicating increasing returns to scale in mustard cultivation. This suggests that a 1 % increase in all inputs would lead to a 1.070 % increase in mustard yield.

3.4 Potentials and challenges of mustard production

SWOT analysis is a valuable tool used for strategic planning and decision-making. The SWOT analysis (Uddin *et al.*, 2024) of mustard production is given in Table 7. The important strength of mustard cultivation was a large domestic market (62.4%), followed by a favorable climate (67.6%) and relatively low production cost (56.4%).

Table 7: SWOT analysis of mustard production (% of farm household responded)

Strengths	% of farmers responded	**Opportunities**	% of farmers responded
Favourable climate	169 (67.6 %)	Growing demand for mustard oil	211 (84.4%)
Large domestic market	156 (62.4%)	Developing improved varieties	198 (79.2%)
Relatively low production cost	141 (56.4%)	Improved storage and processing techniques	177 (70.8%)
Weaknesses		**Threats**	
Low yield	54 (21.6%)	Drought during the season	43 (17.2%)
Limited use of high yielding varieties	111 (44.4%)	Uneven rainfall	52 (20.8%)
Traditional farming practice	187 (74.8%)	Attack of pests and diseases	122 (48.8%)

However, limited use of high-yielding varieties (44.4%), followed by traditional farming practices (74.8%) and low yield (21.6%), was found to be the major weakness of mustard production. Farmers also responded that mustard production was growing demand for mustard oil (84.4%), followed by improved storage and processing techniques (70.8%) and development of improved varieties (79.2%). Besides, the crucial threats to mustard cultivation were the attack of pests and diseases (48.8%), followed by uneven rainfall (20.8%) and drought during the season (17.2%).

IV. CONCLUSIONS

To achieve the objectives of this study, descriptive and econometric analysis were applied. To explore the contribution and productivity of the individual inputs, a production function analysis was carried out. In this study area, based on their socioeconomic, demographic, and mustard characteristics, most mustard farmers were older and had graduated from Secondary School, while very few had a Share Crop type of land tenure. Most farmers were growing mustard on their own land with an average medium-sized holding. Mustard seed was primarily obtained from the BADC while seeds supplied by companies were infrequent. The majority of mustard farmers did not have formal training in agriculture. The decision to grow mustard was influenced by their neighboring farmers. Irrigation of mustard was least likely to be carried out using natural water sources (e.g., rivers, lakes) and was most often performed using electric pumps. The BARI-14 was by far the most commonly grown variety of mustard in this study area and BINA-11 was the least commonly grown variety. Only 17% of farmers received any form of support services, such as credit facilities, and approximately 2% followed the recommended soil p^H level while only 32% of farmers received extension services. The profit analysis on a per-acre basis indicated that it would have been financially profitable. The benefit/cost ratio (1.02) indicates that mustard farmers receive modest financial returns from the production of their crops. Analysis of a Cobb-Douglas production function indicates that human labor, machine use, seeds and irrigation are the main factors that affect production. The high value of the overall model fit - an F-value of 186.450 at the 1% significance level - indicates the high degree of confidence in the estimates of the model.

However, mustard growers also face a variety of challenges, including limited access to institutional credit and complicated loan documentation, a lack of training and access to agricultural inputs, a lack of scientific knowledge, low local market prices, limited access to quality seeds, insufficient government support and disease and pest issues. Therefore, if these roadblocks were removed, it would be easier for farmers to produce mustard efficiently and potentially achieve self-sufficiency. To optimize productivity for mustard farmers, there should be better quality, stress resistant seeds developed, practical access to modern farming technologies through more participatory training programs for many farmers and for improved access to technological knowledge and practices and ensure that prices paid to mustard farmers will not only match the cost to produce but also provide farmers compensation for their work. There should also be encouragement for collective farming so that farmers can share input costs while also enhancing their collective negotiating power. The government should also invest in enhancing its agricultural co-operatives and strengthen its agricultural extension services to assist farmers in improving their operations. Without examining the Quantitative Strategic Planning Matrix (QSPM), this analysis concentrates on the agricultural process, financial considerations and farmer characteristics. The researcher advises future researchers to take a more comprehensive view of market dynamics, legislative actions and other variables that may affect mustard production. This study was carried out in a small area which helps upcoming researchers to carry out broad perspectives.

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Appendix 1: Result of Multicollinearity Test

Variable	**Tolerance**	**VIF**
Irrigation	.968	1.034
Human labor	.361	2.770
Machinery	.982	1.018
Seed	.369	2.709
Fertilizer	.941	1.063