ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 51(1): 461-471, March 2026

DETERMINANTS OF ONION YIELD VARIATION AMONG FARMERS IN PABNA DISTRICT, BANGLADESH: EVIDENCE FROM AN ORDERED LOGISTIC REGRESSION MODEL

S. ISLAM[1], M. RASEL[2] AND N. MOHAMMAD[3]

Abstract

Many socioeconomic, institutional, and biophysical factors contribute to substantial variation in onion yields among growers in Bangladesh in general and in Sujanagar upazila of Pabna district in particular. The main objective of the present study was to identify factors affecting the probability of onion yield falling into low, medium, or high categories, given a set of yield-determining inputs. Primary data collected from 40 randomly selected onion growers in Sujanagar upazila were analysed using a proportional odds (ordered logistic) model. The study finds that several socioeconomic and agro-ecological variables-, such as farmer age, plot size, onion variety (Kings and Taherpuri), farming experience, and fertilizer use- significantly influence onion yield categories. Therefore, it is imperative to provide greater support to small farmers and arrange training programs and extension services to enhance farmers' skill and experience. Moreover, agricultural advisory services should emphasize the appropriate use of fertilizers, pesticides, and weedicides to enhance onion yields in the study area.

Keywords: Ordered logistic regression, Proportional odds, Onion, and Yield categories

Introduction

Flavouring food by adding different plant parts during cooking or in the preparation of pastes or salads is a common practice worldwide (Islan *et al*., 2011). In this case, spices play a vital role. Onion is one of the most important spice crops and is widely used in daily diets on a large scale. In preparing soup, meat dishes, salads, sandwiches; it is extensively used as a condiment and sometimes is cooked alone as a vegetable (Vohra *et al*., 1974). The diversified use of onions has increased their importance among all the spices. Onion is widely consumed across the world, with an estimated demand of about 25g/capita/day (Akter *et al*., 2023). Onion ranks second globally in terms of area under cultivation (Bapari *et al*., 2016). Among other competing spices, onion production is considered more lucrative (Mila and Parvin, 2019).

Onion is the most important spice crop for Bangladesh's people, as it is considered indispensable in daily cooking (Anjum and Barmon, 2017). Almost all food dishes

[1]Department of Agricultural Economics, Gazipur Agricultural University (GAU), Gazipur, and [2&3]Agricultural Statistics and ICT Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

are prepared using it. Among all the spices, onion takes the first place in Bangladesh based on the daily intake (35-40 g/day/person) (Khan *et al*., 2024). In total, about 2.04 lakh hectare area is used for onion production in our country, which produces about 25.47 lakh MT/year, but the average yield (13.78 t/ha) is very low compared to the world's onion yield (BBS, 2023). Consequently, the Government has prioritized the agriculture sector by providing subsidies and input support to increase onion production (Fatima, 2021). Being a widely used spice, Bangladesh has a vast demand for onion, but the country faces difficulty in meeting even 15% of the annual requirements of onion through domestic production (Hossain *et al*., 2017). Therefore, every year the country needed to import between 0.9 to 1.1 million tons of onion from the neighbouring countries. This results in an annual expenditure of approximately Tk. 4 lakh crore in foreign currency (Jubayer *et al*., 2024).

Onion is grown in all districts of Bangladesh, but among them, Pabna has the largest onion production rate. About 800,000 tones onion is produced in Pabna district alone, which is one-third of the total production (BBS, 2023). Despite being a leading onion-producing district, productivity in Pabna remain low and insufficient (Haque *et al*., 2011). For increasing onion yield, the agricultural extension department is trying to promote improved technologies, but the national average onion yield could not go up from 13.78 t/ha with higher yield variations among farmers (Khan *et al*., 2024). Again, farmers follow different management practices depending on their infrastructure and socioeconomic conditions, which ultimately leads to variability in yields (Zegeye *et al.,* 2024). Past research identifies that various onion growers in the country are getting much below or above the average national onion production. Therefore, it is essential to identify the socio-economic and biophysical factors that determine farmers' placement into low, medium, and high onion yield groups. Several studies have been conducted at global, national, and regional levels on onion production, productivity, technical efficiency, and so on. To the best of the authors' knowledge, limited empirical evidence exists on yield-category variation of onion in Bangladesh. The study was, therefore, was conducted to explore the scenario of onion yield in Pabna district and determine the factors affecting the onion yield variation among the farmers of Pabna district.

Materials and Methods

Study area

The study area was carefully selected to ensure the representative results. So, we selected the Pabna district purposively. Subsequently, Sujanagar upazila was purposively selected, and farmers were chosen randomly. The rationale behind this selection is that Pabna district is predominantly agro-based and onion is the second

most dominant crop (first is jute). Farming is the principal occupation of the majority of the population, and livelihoods largely depend on agricultural activities.

Data sources

The present study primarily relies on farm-level primary data; therefore, a survey was conducted in the Pabna district. A well-designed and pre-tested questionnaire was used to collect both quantitative and qualitative information. Data comprised household's socioeconomic characteristics (household education level, farming experience), land holding (agricultural land, plot size, land ownership, area under onion), farm input utilization (fertilizers, pesticides, weedicides), farm output (onion yield). Secondary information was collected from published and unpublished documents to support research findings.

Exploratory data analysis

Initially, descriptive (Table 1) and inferential analyses were conducted to understand the characteristics of the data. Then, to meet the objectives, ordered logistic regression also known as proportional odds model was applied to identify the factors impacting onion yields at different yield groups of low, medium, or high. This category is made inspiring the national minimum yield 13.78 t/ha and maximum yield 19.7 t/ha (Khan et al., 2022), because, instead of arbitrarily defining "low" or "high" yield categories, the national minimum-maximum yield provides a data-driven and scientifically defensible threshold for classification. Previous research suggests that variation in yields of crops of the study area is a common feature on grounds of varying agro-ecological and socio-economic conditions of the households. Present study also proves this, for example, some farmers achieved onion yield much below the mean yield level of the sample farmers and others crossed yield beyond the mean yield. In practice, ordered logistic or ordered probit regression models are suitable for analysing yield variation when the dependent variable is categorical. Here, onion yield are categorised using nationa categories of low, medium or high were regressed on some explanatory variables through ordered logistic regression. We know that soil parameters are considered important explanatory variables that may have influence on the variation of production. But in this study, the data collection was confined to 2-3 nearby unions within the same upazila and generally, no difference is found in the soil parameters between the nearby unions. Therefore, soil parameters were not included as explanatory variables in this study. In current study, yield categories are taken as 1, 2, and 3 to represent low, medium or high yield groups. By comparing average yield of sample farmers with the world's average onion yield, we have developed categories of dependent variable.

Table 1. Descriptions and measurements of variables

Variable	Measurement	Description
Yield group	Low, medium, and high	Group 1 = low, yield less than 13.78 ton/ha, 2 = medium, yield within ≥ 13.78 and ≤ 19.7, and 3 = high if more than 19.7 ton/ha
Education	Below SSC, above SSC	Respondent's education, 1= below SSC, and 2= above SSC
Age group	Young, middle-aged, and old-aged)	Group 1= young, age up to 35 years, 2= middle aged, 36 to 50 years, and 3= old aged, above 50 years
Plot size	Marginal, small, and medium	Group 1= marginal farm, up to 0.2 ha, 2=s mall farm, 0.21 to 1.0 ha, and 3= medium farm, 1.01 to 3.0 ha
Variety	Hybrids, Kings, Rani-1, Sukhsagor, Taherpuri	Farmer's used o nion variety, 1= Hybrids, 2= Kings, 3= Rani-1, 4= Sukhsagor, 5=Taherpuri
Fertilizer	kg	Quantity of fertilizers used in total kg per hectare
Pesticides	Sprays	Number of pesticide sprays on the onion vegetable
Weedicide	Sprays	Number of weedicide sprays for weed management
Prior harvest	Yes/No	Farmers harvest some onions before harvesting time, yes, or no
Land owner	Self/Lease	Land ownership of the respondents, 1= self, and 0 otherwise
Experience	Low, medium, High	Onion cultivation experience, low = 1, up to 5 years of, medium = 2, 6 to 11 years, and high=3, above 11 years

An ordered logistic model estimates the probability of falling into a specific category based on the independent variables, assuming that the effect of these variables is consistent across all categories of the dependent variable.

$$P_{ij} = P_r(y_j = i)P_r(k_{i-j} < x_j\beta + u_j \leq k_i) = \frac{1}{1+\exp(-k+x_j\beta)} - \frac{1}{1+\exp(-k-1+x_j\beta)}$$

Here, y_j is supposed to be logistically distributed in ordered logit and the coefficients of β (β_1, β_2, β_3,.., β_k) along with the cut-points k_1, k_2,...,k_{k-1}, where k means the number of possible outcomes.

Statistical software

Data input, organization, manipulation, editing, report, recoding etc. were conducted using Excel. Statistical measures as a number, range, mean, variance, standard deviation etc. were used in describing the variables whenever applicable. Exploratory data analysis and ordinal logistic regression were conducted using R Studio, version 2024.12.1+563. In this study, R software was used for our analysis, and extreme events. And the rest of the works were done in an Excel File.

Results and Discussion

Descriptive results

According to preliminary results, the average yield is estimated as 17.87 t/ha, ranging from 10.18 to 26.14 t/ha (Table 2). Two key observations emerge from these results. First, a wide output difference among farmers is evident from the values of variance and standard deviation. Second, the average yield seems to follow normality due to the median yield of 17.61 and the coefficient of skewness of -0.03 (fairly symmetric). Therefore, greater efforts are required to reduce the wide yield gap between low- and high- onion growers. Moreover, the current onion yield of 17.87 t/ha in Pabna district is well above the national average onion yield of 13.78 t/ha in the country.

Table 2. Descriptive statistics of yield

Parameters	Yield (t/ha)
Average	17.87
Standard deviation (SD)	4.10
Minimum	10.18
Maximum	26.14
Median	17.61
Variance	16.81
Skewness	-0.03
No. of observations	40

Table 3 below reveals frequency, percent of farmers, and average yields coming under three onion yield levels. A large number of respondents (47.5%) obtained a yield of the middle category, covering yield from 13.78 to 19.7 t/ha. So, it appears that the medium level category would have a higher probability of entering into a higher onion yield category. Around 37.5% farmers could obtain a high yield level, while about 15% achieved a low yield level. All this implies that the combined probability of both low and medium farmers might be higher of entering into the

higher yield category than large farmers, as evident from the joint percentage (62.5%) of farmers subject to providing appropriate farm input packages and given their prevailing socio-economic and agro-ecological characteristics.

Table 3. Statistics on average yield by category

Statistics	Frequency	Percent	Cumulative percent	Mean yield	SD
Low	6	15	15	11.46	1.17
Medium	19	47.5	62.5	16.54	1.66
High	15	37.5	100	22.12	1.86
Total	40	100		17.87	

SD = Standard Deviation

Econometric Results

Table 4 presents ordered logistic regression estimates using R Studio. Total 40 observations used in the analysis are displayed at the start of the output table. The model was compared with a saturated model (Likelihood ratio value and associated p-value are shown in the table) and no significant difference was observed, hence the model can explain the variability of onion yield reliably. We can see that the predictor variables significantly affect the onion yield categories of onion growers. The effect of individual variables is elaborated with reference to respective coefficients and associated t-values with two-tailed *p*-values. Positive coefficients indicate that higher levels of these variables increase the likelihood of farmers attaining higher onion yield categories. Conversely, farmers with more units of the variables may have less probability of entering into a higher yield group.

Overall, 5 variables are found statistically significant but with different significance levels and signs. Positive and significant coefficient holder variables inform that, remaining variables included in the model being the same, farmers of old age, having a small plot, having medium or higher level of experience of onion cultivation, and using fertilizer tend to have higher onion yield levels per hectare. On the contrary, the Kings and Taherpuri varieties are negatively but significantly affecting onion production.

Holding other variables constant, for old farmers, the log odds of being in a higher yield category versus the combined low and medium yield categories are higher than those of young farmers. This may be because old farmers tend to be more experienced and bear greater responsibility for the household livelihoods. Generally, they are more devoted to farming activities than the young farmers. This ultimately contributes to higher onion yields.

Keeping other variables constant, for the farmers who have cultivated onion in a small plot, the log odds of obtaining higher onion yield versus the combined low and medium yield categories are higher than the farmers who use marginal plot size. This confirms that farmers with small plot sizes allow them to produce a greater quantity of onions which enable them to derive greater benefits from onion production than farmers having marginal plot.

Furthermore, some of the varieties of onion also significantly affect the onion yield. Holding other variables constant, for the farmers using Kings variety, the log odds of being in a higher yield category versus the combined low and medium yield categories are less as compared to the farmers using Hybrid variety. Similarly, for the farmers using Taherpuri variety, the log odds of being in a higher yield category versus the combined low and medium yield categories are less as compared to the farmers using Hybrid variety if other factors remain constant.

Farming experience in onion production has a positive and significant effect on onion yield. Assuming other factors remain unchanged, for the farmers who have medium experience in farming, the log odds of being in a higher yield category versus the combined low and medium yield categories are higher than the farmers who have low farming experience. Again, for the farmers who have higher experience in farming, the log odds of being in a higher yield category versus the combined low and medium yield categories are higher than the farmers who have low farming experience if other factors remain constant. This indicates that experience in years that the farmer would have engaged in onion production improves the farmer's abilities in production as farmers becoming more familiar with the production environment and gaining greater expertise in onion cultivation. This helps to the greater onion yield in fact.

Keeping other variables constant, the farmers may have more probability of obtaining higher onion yield versus the combined low and medium yield categories if they apply more fertilizers. For example, one unit (kg in this case) increase in fertilizer, we expect a 0.14 increase in the log odds of being in a higher yield level versus the joint effect of low and medium categories. This indicates that the use of fertilizer enhances onion production by improving soil fertility and providing essential nutrients to the onion crop.

Some variables such as pesticides, prior harvest, land ownership, weedicides and education are not significantly affecting the yield categories but still these bear theoretically expected signs. For example, pesticides and weedicides have positive signs while prior harvest, land ownership and education variables have negative signs. Applying pesticides and weedicides have more probability of going to a higher onion yield group as evident in results of ordered logistic regression. The farmers who have done prior harvest may have less probability of shifting to a higher yield category than farmers who haven't done prior harvest. Again, the

farmers who have own land, may have less probability of being in a higher yield category than the farmers who have leased land. Moreover, farmers above SSC education may have less probability of shifting to a higher yield category than the farmers below SSC level of education.

Table 4. Parameter estimates for three yield groups

Ordered logistic regression		Observations		40
Variables	Coefficient	SE	t-value	p-value
Young (ref. category)				
Middle-age	9.53	6.23	1.52	0.126
Old age	12.61	6.61	1.90	0.056*
Marginal plot (ref)				
Small plot	34.18	6.54	5.23	0.000***
Hybrid (ref)				
Kings	-33.10	9.27	-3.57	0.000***
Rani-1	-9.45	7.93	-1.19	0.233
Sukhsagor	-2.58	14.61	-0.18	0.859
Taherpuri	-100.99	6.54	-15.44	0.000***
Pesticides	5.73	8.13	0.74	0.481
No prior harvest (ref)				
Prior harvest	-6.42	9.12	-0.70	0.481
Land ownership lease (ref)				
Land ownership self	-4.37	3.52	-1.24	0.214
Low experience (ref)				
Medium experience	16.63	3.00	5.54	0.000***
High experience	17.48	3.03	5.77	0.000***
Fertilizer	0.14	0.08	1.66	0.096*
Weedicides	8.93	5.60	1.59	0.111
Education below SSC (ref)				
Education above SSC	-6.34	12.39	-0.51	0.609
1|2	17.62	4.62	3.81	0.000
2|3	73.18	16.45	4.44	0.000
Likelihood Ratio and P-values				9.13 and 1.0

Note: *P≤0.1; **P≤0.05; ***P≤0.01; SE = Standard Error

Zegeye *et al*., (2024) explained the factors which have a great impact on onion production in Raya Kobo district, Ethiopia. They found that factors such as gender, age, education level, experience, labor force, land size, access to extension services, irrigation water, land plough frequency, and fertilizer availability have positive and significant influence on onion production among farm households in the study area. However, excessive fertilizer use was found to have a negative effect. On the other hand, our study has found out that farmer's age, plot size, experience, variety of onion, and fertilizer use can significantly affect the onion yield categories. Among them, old farmers, small plot size, medium or higher experienced farmers and fertilizer use have positive effect which can enhance the onion yield of higher levels. Education level is not significant in this study but it was found from the paper of Zegeye *et al*. (2024) education as a positive and significant variable. Again, they didn't include variety of onion which is one of the most important explanatory variables that has significant effect on onion yield variation among farmers.

Limitations

This study has several limitations that should be considered when interpreting the results. First, the relatively small sample size may limit the statistical power and increase the variability of the estimated effects. Second, some extremely large coefficient estimates observed in the model could indicate potential overfitting or the influence of outliers, which may distort the true relationships between variables. Third, the choice of model may not fully capture the underlying data structure, and alternative model specifications might provide different insights. Finally, given these constraints, caution should be exercised in generalizing the findings to other contexts or for future projections, as the results are specific to the study conditions and dataset used.

Conclusion

The main aim of this study was to identify socio-economic and farm-input factors that influence farmers' placement into low, medium, and high onion yield categories. Using data collected from randomly selected farmers in Pabna, an ordered logistic regression analysis was conducted to understand the factors behind onion yield variation. The results highlighted several important variables, including older farmers, small plot size, medium or high farming experience, and fertilizer use, which positively contribute to achieving higher onion yields. These findings show that demographic, socio-economic, institutional, and farm-specific factors all play a key role in explaining yield differences among farmers,

emphasizing the need to consider a wide range of influences when aiming to improve onion production in the study area.

Recommendations

Based on these findings, it is recommended to strengthen agricultural extension services so that farmers receive practical farm management advice and can enhance their farming experience. Providing additional support and facilities to smallholder farmers can help them achieve higher onion yields. Efforts should also focus on the proper and balanced use of fertilizers, pesticides, and weedicides to increase production efficiency and improve yield quality. Finally, implementing training programs for medium and highly experienced farmers can further boost productivity by promoting best agronomic practices. Together, these measures can help reduce yield variation and support higher onion production in the study area.

References

Akter, S., K. T. Rahman, A. R. Anik, and M. R. Amin. 2023. Growth and trend analysis of onion production in Bangladesh. *Annals of Bangladesh Agriculture* **27**(2): 201-210.

Anjum, A., And B. K. Barmon. 2017. Profitability and comparative advantage of onion (Allium cepa) production in Bangladesh: An economic study in some selected areas. *The Agriculturists* **15**(2): 66-78.

Bapari, M. Y., M. K. I. Chowdhury, M, M. E. Haque, and A. Al-Mamun. 2016. Economic analysis of onion production in Sujanagar and Santhia areas of Pabna, Bangladesh. *International Journal of Humanities and Social Science Invention* **5**(10): 5-12.

BBS. 2023. Yearbook of Agricultural Statistics of Bangladesh-2023. 35th Series, Published: June 2024. Bangladesh Bureau of Statistics, Statistics & Informatics Division, Ministry of planning, Government of the People's Republic of Bangladesh, p. 144, 162.

Fatima, M. K. 2021. Use of modern onion cultivation practices by the farmers of Pabna district (Doctoral dissertation, department of agricultural extension and information system, Sher-E-Bangla Agricultural University, Dhaka-1207).

Haque, M. A., M. M. Miah, S. Hossain, M. S. Rahman, andM. Moniruzzaman. 2011. Profitability of onion cultivation in some selected areas of Bangladesh. *Bangladesh Journal of Agricultural Research* **36**(3): 427-435.

Hossain, M. M., F. A. R. U. Q. Abdulla, and I. Parvez. 2017. Time series analysis of onion production in Bangladesh. *Innovare Journal of Agricultural Science* **5**(1): 1-4.

Islan, M. S., K. M. Rahman, M. K. Hasan, and K. M. Adnan. 2011. Present Status and Potentiality of Onion Production in Bangladesh. *Bangladesh journal of political economy* **27**(1-2): 253-264.

Jubayer, M. A., M. A. Alam, M. F. Imam and M. F. Hasan. 2024. Growth, Instability in Production and Price Forecasting of Onion in Bangladesh. *Journal of the Bangladesh Agricultural University* **22**(3): 377-385.

Khan, M., M. Rahman, and R. Sarker, R. 2022. Effect of variety and seed rate on yield and quality of onion (*Allium cepa* L.) SETS. *Program Leader*, 244.

Khan, M. A., M. M. Haque, M. A. Islam, R. Sarker, and M. M. Rahman. 2024. Effect of technological interventions on yield gap analysis and profitability of winter onion (*Allium cepa* L.) varieties. *Archives of Agriculture and Environmental Science* **9**(4): 722-727.

Mila, F. A., and M. T. Parvin. 2019. Forecasting area, production and yield of onion in Bangladesh by using ARIMA model. *Asian Journal of Agricultural Extension, Economics & Sociology* **37**(4): 1-12.

Vohra, S. B., M. Rizman. And J. A. Khan. 1974. Medicinal use of common Indian vegetables. *Planta Medica* **23**(4): 381-393.

Zegeye, M. B., T. A. Alemu, M. A. Sisay, S. G. Mulaw, S. G., and T. W. Abate. 2024. Factors affecting onion production: An empirical study in the Raya Kobo district, Amhara regional state, Ethiopia. *Plos one***19**(6):134-305.