

Growth and Supply Response of Winter Vegetables Production in Bangladesh

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Abstract

The study estimated growth rates and supply response functions for winter vegetables in Bangladesh using time series data. Growth analysis revealed that area indices for various vegetables considering five years moving average showed an overall increasing trend over the period from 1970-1974 to 2000-2004. The production indices of different winter vegetables showed also an increasing trend over the period from 1970-1974 to 2000-2004 with slight exception in the production of brinjal. The average growth rates of winter vegetables area and production were 2.26 % and 2.92 % during pre-adoption period (1970-1990) and 3.68 % and 3.6 % during post adoption period (1991-2006) respectively. Significant structural changes occurred in the area and production of various winter vegetables during post adoption period due to policy effect and autonomous production as well. Positive structural change has also been registered in the yield of winter vegetables due to adoption of improved variety. Supply response functions fitted for various vegetables revealed that lagged area and relative yield risk significantly influenced farmers to allocate land under tomato and radish

Keywords: growth, lagged relative price, lagged relative yield

Introduction

Vegetables crops assume great importance in Bangladesh in view of the serious problem of malnutrition that persists in this country. Majority of the population in Bangladesh suffer from severe malnutrition which has a negative effect on the development of the physical and mental growth. Severity of malnutrition and iron deficiency (anemic) is the highest among the children and female member of all age groups. Over 30,000 children become blind each year due to sever vitamin A deficiency. The average diet in the Bangladesh is deficient in almost all of the major nutrients, especially vitamins (vitamin A riboflavin, vitamin C and minerals). Vegetables are rich in protein and calcium sources. Vegetable are not merely items of food, they are also commodities for domestic and international trade and raw materials for the processing industry. Vegetables occupy 16%

of the total cultivated land area of Bangladesh (BBS, 2006). It is extremely difficult to estimate accurately the total area under vegetables and total production because of scattered small holdings.

Bangladesh has a unique the climate for vegetable production. The year is divided in to two distinct seasons: rabi (winter from October to March) and kharif (hot humid season from April to October).

The rabi season is suitable for most of the vegetable crops due to relatively low temperature, humidity and rainfall. To improve vegetable production and supply we should develop varieties suitable for growing in the adverted weather conditions of the kharif season and drought resistant varieties for the rabi season. To determine the trends of different types of vegetables, it is therefore, essential to examine the past performance so that the magnitude and direction of the changes of the crops can be easily detected. Structural

changes in the vegetable production between pre and post policy reform period is needed to know whether is only due to policy effect or autonomous production. The structure of agriculture may be influenced by various price and non-price factors.

Supply response functions provide us with useful information on the extent of farmer's response to price and other economic factors. Price factor can change the relation thing between price and quantity demanded. On the other hand, non-price factors can change the relationship between price and quantity supplied. Therefore, the present study attempts to analyze the growth demeanor and factors influencing the supply of various vegetables in Bangladesh

The specific objectives of this study are: 1) to determine the growth rate of area, production and yield of various winter vegetables. 2) To estimate the structural change in the production of different winter vegetables. 3) To assess the effect of price factors on the acreage response of some winter vegetables. 4) To give some policy guidelines.

Materials and Methods

Time series data on area, production and yields of different winter vegetables for 35 years from 1971/72 to 2005/06 were obtained from the year book of Agricultural statistics of Bangladesh. The whole period (1971/72-2005/06) was divided into two major periods viz periods I (1970/71-1990/91) and periods II (1991/92-2005/06) to compare the rate of changes occurred in the area, production and yield of different winter vegetables and explore the causes of changes.

Measuring the Trend of Change

Five year moving average was used to estimate trend and indexes were prepared to compare the change in area, production and yield of different vegetables considering 1970-1974 as base period. Five year moving average was taken because period of time was very long (30 years). In addition, variation observed in area, production and yield were not so fluctuated. The formula used for calculating index number was follows.

$$\text{Index} = \left[\frac{(\text{Current year value} - \text{Base year value})}{\text{Base year value}} \times 100 \right] + 100$$

Growth Rate Estimation

The growth rates of area, production and yield of vegetables were worked. Out by filling a semi-log function of the following type:

$$Y = e^{bt} \quad \text{or} \quad \ln Y = \ln a + bt$$

Where, Y = Area (ha) or production (ton) or yield ($t \text{ ha}^{-1}$), t = time period (year)

Test of Structural Stability

It was assumed that the effect of policy reform might influence vegetables production during post adoption period (1991-2006) as number of improved vegetables technologies were developed and disseminated to the farmers during these periods. In that period, government has to emphasize for open market economy and agricultural subsidy was the highest. As a result, particular dates were chosen. Structural stability test was performed to verify the structural changes occurred in the area, production and productivity of different vegetables between two periods. In this study from 1970 to 1990 was treated as period-I (non adoption period of improved vegetables variety and from 1991-2006 was treated as period-II (adoption period of improved vegetables variety). Dummy variable technique was used to test the structural stability. The regression model used in the study was as follows.

$$\ln Y_i = \beta_1 + \beta_2 D_i + \beta_3 X_i + \beta_4 D_i X_i + U_i$$

Where, Y_i = Area (ha) or production ($t \text{ ha}^{-1}$) or yield ($t \text{ ha}^{-1}$) of different vegetables in i th year; D_i = period dummy (1 for 2nd period, other wise 0); X_i = Time ($i = 1, 2, 3, \dots, 35$). β_1 is general intercept; β_2 is differential intercept; β_3 is coefficient of time and β_4 is differential slope coefficient. β_2 indicates the significant change occurred in the 2nd period. On the other hand, β_4 indicates how much the slope coefficient of 2nd period differs from the slope coefficient of 1st period. It means that the rate of change occurred in period II over time. When $D_i = 1$, then $\ln Y_i = (\beta_1 + \beta_2) + (\beta_3 + \beta_4) X_i = \gamma_1 + \gamma_2 X_i$ When $D_i = 0$, then $\ln Y_i = \beta_1 + \beta_3 X_i$

The null hypothesis of the structural stability test is $H_0 : \gamma_1 = \beta_1$ and $\gamma_2 = \beta_3$. If the 1st null hypothesis is accepted then it indicates that there is

no change occurred in the 2nd period, which is originated from the intercept (due to autonomous production). If the 2nd null hypothesis is accepted then it indicates that there is no structural change occurred in the 2nd period, which is originated from the slope coefficient (due to adoption effect). The estimated elasticity coefficient of different supply response variables are shown in Table 5 and discussed below.

Estimation of Supply Response

Nerlovian partial adjustment lag model (Nerlove, 1956) was used for estimating supply response for various winter vegetables production in Bangladesh. The model implies that the change in current area is in proportion to the difference between the long run equilibrium area and an actual area in the previous year. The double log (natural) form of the Nerlovian Partial model was employed in view of its suitability to the data. Hence we get the following basic equations.

$$\ln A_t = b_0 + b_1 \ln RP_{t-1} + b_2 \ln RY_{t-1} + b_3 \ln CV_{RP} \\ + b_4 \ln CV_{RY} + b_5 \ln A_{t-1} + U_t$$

Where 't' always refers to the production period.

A_t = The actual area (ha) planted under the vegetable concerned, which is used as a dependent variable.

A_{t-1} = One year lagged area (ha) under the winter vegetable concerned.

RP_{t-1} =Lagged relative price, i.e. Ratio of the prices of own and competitive crop (Brinjal was the competitive crop).

RY_{t-v} =Lagged relative yield, i.e. ratio of the yield of the vegetable concerned to yield of the competitive crop.

$CVRP$ and $CVRY$ =Co-efficient of variation of the preceding years relative price and relative yield respectively

U_t = Error term

Results and Discussion

The area indices showed an overall upward trend over the period from 1990-1994 to 2000-2004. The area under brinjal slightly decreased over the period from 1980-84 to 1985-89 compared to the base year of 1970-1974 (Table 1). According to

Table 1, the greatest increase was in radish, rising from 100 in 1970/74 to 232 in 2000/04. However, the area indices for cauliflower, cabbage, and radish represented an impressive increasing trend over the period from 1970-74 to 2000-2004.

The indices prepared for the production of different winter vegetables showed an increasing trend over the period from 1970-74 to 2000-2004 with slight exception in the production of brinjal. Brinjal production dropped significantly during 1985-89 to 1990-1994 (Table 2). The reasons behind this decrease might be due to susceptibility of brinjal production to insect (fruitfly) and diseases (soil borne). Besides, the cultivations of other vegetables like cauliflower, tomato and radish were more profitable than brinjal to the farmers. On the contrary, the index of cabbage production rose dramatically compared to its areas might be due to higher productivity. Nevertheless, the production of cauliflower, Tomato and Radish increased during 2000-2004 compared to its base period as well as its previous periods. The changes of area and production of vegetables over the period were mostly similar to the changes found in the yield of vegetables. For this reasons, indexes of yield were not calculated.

Rate of Change in Area, Production and Productivity of Winter Vegetables in Bangladesh

Compound growth rate using formula, $Y = ae^{bt}$ of selected vegetables may be calculated separately during period I, period II and whole period. The area and production of cauliflower, cabbage, and radish registered higher growth rates, while brinjal and tomato were found less growth rates over the period of 36 years (1970-2006). The overall growth rate (3.12) of winter vegetable production was higher than the growth rate (2.66) of area (Table 3). The Table further shows that the average growth rates of selected vegetables area and production were 2.26% and 2.92% during pre-adoption period (1970-1990) and 3.68% and 3.6% during post adoption period (1991-2006) respectively. Because of adopting improved technology and variety development the area and production of vegetables registered higher positive growth rates during post adoption period. Brinjal witnessed the highest growth rates during post-adoption period which were 6.7% and 6.3% in area and production

Table 1 Index of area under some winter vegetables in Bangladesh.

Year	Vegetable name					
	Brinjal	Cauliflower	Cabbage	Tomato	Radish	All
1970-74	100	100	100	100	100	100
1975-79	104	113	111	109	123	112
1980-84	101	139	133	122	149	129
1985-89	102	150	140	142	180	143
1990-94	106	161	164	156	205	158
1995-99	162	200	201	177	218	191
2000-04	219	229	230	217	232	225

Sources: BBS (1983, 1990, 1996, 2006)

Table 2 Index of some winter vegetables in Bangladesh.

Year	Vegetable name					
	Brinjal	Cauliflower	Cabbage	Tomato	Radish	All
1970-74	100	100	100	100	100	100
1975-79	114	113	110	101	127	113
1980-84	111	154	139	114	157	135
1985-89	112	171	152	133	367	187
1990-94	102	200	189	147	243	176
1995-99	144	223	257	160	268	210
2000-04	189	262	302	185	282	244

Sources: BBS (1983, 1990, 1996, 2006)

respectively. Likewise, the overall productivity of all selected winter vegetables except brinjal and tomato increased during 1970-2006 period due to adoption of improved technologies (Table 3).

Structural Stability Test

Table 4 illustrates that the differential intercepts (β_2) of area and production of different winter vegetables are highly significant and 1st null hypotheses for all vegetables except cauliflower are rejected. There are significant production of different vegetables between pre-adoption period (1970-1990) and post adoption period (1991-2006). On the contrary, the differential intercepts of production in cauliflower are not significant and the corresponding null hypotheses are accepted implying that there was no significant difference in the production of this vegetable between two periods. However, the differential slope coefficient

(β_4) indicates the nature of changes occurred in the area and production of different winter vegetables over time.

The 2nd null hypotheses are accepted for radish and cauliflower indicating that there was no structural change in 2nd period. For rest of the vegetables, the 2nd null hypotheses are rejected indicate that there are structural changes in the area and production during post adoption period due to policy effect and autonomous production as well. Tables 4 further reveal that differential intercepts (β_2) of various vegetables yield are statistically significant implying that there are significant differences between two periods. Again, the differential slope coefficient (β_4) of different winter vegetables yield are positively significant indicating that there are positive structural changes in the yield of these vegetables during post-adoption period due to adoption of improved variety.

Table 3 Rate of change in area, production yield of some winter vegetables in Bangladesh.

Year	Vegetables name					
	Brinjal	Cauliflower	Cabbage	Tomato	Radish	All
Area						
1970-90	0.10	2.8	2.2	2.3	3.9	2.26
1991-2006	6.7	3.3	3.2	3.8	1.4	3.68
1970-2006	2.3	2.8	2.9	2.5	2.8	2.66
%Change ^{1/}	65.144	60.12	63.83	55.06	58.22	38.45
Production						
1970-90	- 0.4	3.7	2.9	2.1	6.3	2.92
1991-2006	6.3	3.9	3.3	3.0	1.5	3.6
1970-2006	2.1	3.3	4.5	2.2	3.5	3.12
%Change ^{1/}	57.92	69.46	231.62	- 45.88	40.70	+ 70.76
Yield						
1970-90	- 0.5	0.9	0.6	- 0.2	2.4	+ 0.64
1991-2006	- 0.3	0.6	- .01	- 0.7	0.1	- 0.62
1970-2006	- 0.2	0.5	1.6	- 0.3	0.7	+ 0.46
%Change ^{1/}	- 3.221	6.85	100.22	- 5.40	4.79	+ 20.64

^{1/} %Change in the mean area/production/yield of period 1991-2006 over 1970-1990.

Supply Response Behaviour of Some Winter Vegetables

Supply response functions provide us with useful information on the extent of farmer's response to price and other economic factors. An attempt has been made here to study the supply response of various winter vegetables namely cauliflower, cabbage, tomato and Radish in Bangladesh during the period 1972/73 to 2005/06. Different supply response functions fitted for various winter vegetables showed that brinjal competed with cauliflower, cabbage, tomato and Radish.

It is assumed that the area under various winter vegetables is likely to be influenced by different variables such as lagged area, lagged relative price, lagged relative yield, relative price risk and relative yield risk. Price is one of the important variables that influence farmers to allocate area for vegetables production. It is evident that farmers produce different vegetables mostly depends on previous year's harvest price. Therefore, the harvest price of vegetables was taken into consideration in this study because wholesale and retail price may not some time reflect the actual price that received by the farmers. On the other hand, the risks due to variations in yield and price are expected to act as

deterrent factors on acreage under various vegetables during a particular year. Therefore, only the price and yield risk or the coefficient of variations of prices and yield of various vegetables for the preceding two years were used in this study as risk variables. The reasons of taking preceding two years, the output particularly yield for any crop for two years or more appears to be a long period to remember for farmers with multi-product farm enterprises. This might be as sufficient way to incorporate risk particularly in the annual time series aggregate model (sidhu and sidhu, 1988).

Supply Response

Lagged area

The elasticity estimates of lagged area have emerged positive and significant for all selected vegetables. It implies that allocation of area under vegetables in the preceding year had significant influence on current year's allocation. The lagged area influence was found higher on the allocation of land for tomato production followed by cabbage, radish and cauliflower. The magnitude of coefficient for tomato is close to 1, indicating that the farmers had considerably high adjustment response (Table 5).

Table 4 Results of structural stability test through dummy variable technique between before and after policy effect of different types of winter vegetables.

Vegetable	Structural stability test ^{1/}								
	β_1 (t-value)	β_2 (t-value)	β_3 (t-value)	β_4 (t-value)	R ² (F value)	$\gamma_1 =$ ($\beta_1 + \beta_2$)	$\gamma_2 =$ ($\beta_3 + \beta_4$)	H ₀ $\gamma_1 = \beta_1$	H ₀ $\gamma_2 = \beta_3$
Area									
Brinjal	9.78*** (4.918)	1.329*** (4.918)	0.001 (.009)	0.062*** (5.62)	0.776 (37.03)	11.109	0.063	Rejected	Rejected
Cauliflower	8.46*** (333.70)	0.107 (1.204)	0.028*** (13.45)	.004 (1.021)	0.970 (347.09)	8.567	0.32	Rejected	Rejected
Cabbage	8.529*** (357.390)	0.245*** (0.023)	0.023*** (3.474)	0.012*** (3.474)	0.973 (396.107)	8.774	0.035	Rejected	Rejected
Tomato	8.839*** (349.47)	0.271*** (3.045)	0.023*** (10.992)	0.011*** (3.009)	0.965 (294.64)	9.11	0.034	Rejected	Rejected
Radish	9.087*** (423.17)	0.544*** (7.213)	0.039 (21.96)	-0.026 (-8.66)	0.979 (506.46)	9.631	0.013	Rejected	Accepted
Production									
Brinjal	11.769*** (150.90)	1.299*** (4.737)	0.006 (0.991)	0.064*** (5.731)	0.748 (36.667)	13.068	0.07	Rejected	Rejected
Cauliflower	10.332*** (231.62)	-0.027 (-0.176)	0.037*** (10.159)	-0.002 (-0.397)	0.936 (158.05)	10.305	0.035	Accepted	Accepted
Cabbage	10.529*** (53.94)	0.191 (0.278)	0.029* (1.791)	0.019 (0.671)	0.588 (15.25)	10.72	0.048	Rejected	Rejected
Tomato	10.882*** (294.62)	0.121 (10.934)	0.020*** (6.565)	0.006 (1.050)	0.905 (101.94)	11.001	0.026	Rejected	Rejected
Radish	10.925*** (88.790)	0.821* (1.895)	0.067*** (6.544)	0.052*** (2.931)	0.921 (27.65)	11.745	0.119	Rejected	Rejected
Yield									
Brinjal	1.982*** (108.56)	0.030*** (0.956)	0.007*** (4.259)	0.002* (0.795)	0.455 (8.93)	2.017	0.9	Rejected	Rejected
Cauliflower	1.871*** (85.921)	0.080** (1.039)	0.010*** (5.425)	0.006*** (2.003)	0.638 (18.81)	1.951	0.016	Rejected	Rejected
Cabbage	1.999*** (10.56)	0.054** (0.081)	0.006 (0.370)	0.007** (0.254)	0.184 (2.41)	2.053	0.013	Rejected	Rejected
Tomato	2.042*** (121.924)	0.150** (2.539)	0.003* (2.122)	0.005** (2.227)	0.581 (14.80)	2.192	0.008	Rejected	Rejected
Radish	1.838*** (15.352)	0.275 (0.653)	0.028*** (2.786)	0.025* (1.459)	0.206 (2.769)	2.113	0.053	Rejected	Rejected

^{1/} *** , ** and * represent 1%, 5% and 10% level of significant respectively.

Lagged relative price

The results of the regression analysis presented in Table 5 show significant positive impact of lagged relative prices on area under cauliflower, radish and tomato. This indicates that the farmers considered the changes in relative prices of cauliflower, radish and tomato while allocating area under these vegetables. On the other hand, the insignificant positive impact was found in the case of cabbage. But the insignificant impact of relative price variable shows that farmers did not consider relation prices while allocating area under these vegetables.

Lagged relative yield

The lagged relative yield of cauliflower, cabbage, tomato and radish with respect to its competing vegetable brinjal has exercised a strong positive and significant impact on area under these vegetables. The short run elasticity of cauliflower, cabbage, tomato and radish with respect to relative yield variable were 2.42, 255, 3.574 and .087 at 1%, 5% and 10% level significant respectively. It implied that farmers considered lagged relative yield during allocation of land for these vegetables cultivation.

Table 5 Estimate of area response functions of some winter vegetables in Bangladesh, 1972-73 to 2005-2006.

Variable	Vegetable ^{1/}			
	Cauliflower	Cabbage	Tomato	Radish
Constant	8.399	8.294	8.68	9.013
Lagged area	0.046** (2.56)	0.079** (2.53)	0.090*** (3.19)	0.058*** (3.072)
Lagged relative price	0.276*** (-2.02)	0.097 (0.653)	0.231* (1.710)	0.388*** (-2.519)
Lagged relative yield	2.42* (6.94)	0.255** (2.063)	3.574** (-2.375)	0.087* (0.651)
Relative price risk	0.020** (-1.08)	0.027 (0.634)	0.026 (0.768)	0.003* (-0.118)
Relative yield risk	0.005 (0.207)	0.015 (0.348)	0.022* (0.784)	0.061*** (-2.775)
R ²	0.811	0.677	0.658	0.715
F-Value	24.052	7.402	6.74	14.11
D-w test statistic	1.942	2.311	1.486	1.965
N	33	33	33	33
D-w test statistic	1.942	2.311	1.486	1.965

^{1/} ***, ** and * represent 1%, 5% and 10% level of significant respectively.

Risk factors

Some winter vegetables considered in the analysis, risk arising due to variations in relative price and relative yield. The elasticity coefficient of risk factors cabbage and tomato were found positive but insignificant. On the contrary, cauliflower and radish were positive but significant. The insignificant relative price risk variable indicates that farmers appear to be risk lovers. On the other hand, farmers considered relative price risk during allocation of cauliflower and radish.

The elasticities of yield risk variable were found to be positive and significant at 1% and 10% level for radish and tomato indicating that the farmers did not consider relative yield risk in cultivating these two vegetables mostly for their households need. However, the yield risk variable was found insignificant for cauliflower and cabbage production which indicated that the cultivation of these two vegetables was influenced by yield risk.

Conclusions

The study has analyzed the growth of area, production and yield of various winter vegetables and estimated the supply response functions for different winter vegetables in Bangladesh. Area

indices show that the area under brinjal slightly decreased over the period from 1980-1984 to 1985-1989 compared to the base year of 1970-1974. Again, cauliflower, cabbage and radish represented an impressive increasing trend over the period from 1970-1974 to 2000-2004. The production indices of different winter vegetables showed an increasing trend over the period from 1970-1974 to 2000-2004 with exception in the production of brinjal. The area and production of cauliflower, cabbage and radish, registered higher growth rates, while brinjal and tomato were found less growth rates over the period of 36 years (1970-2006). Significant structural changes have been occurred in the area and production of various winter vegetables during post adoption period due to policy effect and autonomous change. Yield of winter vegetables increased significantly during post adoption period due to adoption of improved variety. Supply response functions fitted for various vegetables revealed that lagged area and lagged relative yield risk significantly influenced farmers to allocate land for tomato and radish.. They do not consider relative yield risk in cultivating these two vegetables. The lagged relative yield of cauliflower, cabbage, tomato and radish has significant impact on acreage allocation under these vegetables.

Recommendations

Based on the above discussion, it may be inferred that the area, production and yield of winter vegetables increased to some extent during post-adoption period due to adoption of improved varieties. Hence, to accelerate the existing growth rates of vegetables production the following policy guidelines may be taken into consideration.

1. Before taking any price policy, price response level and price flexibility and cross price flexibility effects must be considered further research...
2. Price and yield risk factors will need to be taken care of by appropriate measures of winter vegetables.
3. Non-price factors such as temperature, rainfall, humidity may be considered for future research.

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Manuscript received 19 September 2010, accepted 4 January 2011