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Production, yield and area growth of major winter vegetables of Bangladesh

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Abstract

Winter vegetable production has increased tremendously in Bangladesh. Excessive supply of vegetables reduces the market price that leads to economic loss at farm level. This study assesses the growth and trend of winter vegetables production, yield and area in Bangladesh. Semi-log regression model was used to assess the growth and trend of winter vegetables while Winston Prais transformation was utilized to solve the autocorrelation problem. Yearly time series data of collected from secondary sources was used for this analysis. Data were collected from 1986–87 to 2015–16 years. Data of some major winter vegetables like tomato, *rabi* brinjal, *rabi* pumpkin, water gourd, cauliflower, cabbage, radish, bean, green spinach were collected for this study. Results found that growth of tomato, cauliflower and cabbage production was about 5% which was much higher than other winter vegetables. Growth of cultivated area is about 3% per annum for most of the vegetables. Production of winter vegetables increases because of yield and area growth. Government can attempt to increase export of tomato, cauliflower and cabbage. Moreover, yield growth of green spinach and radish is necessary to increase both production and export.

Introduction

Agriculture has been playing a pioneering role in the growth and stability of the national economy of Bangladesh (Sharmin *et al.*, 2018). The main agricultural commodities of our country are rice, wheat, pulse, jute and different vegetables. Vegetables are considered as one of the most important food crops due to their high nutritive value, relatively higher yield and higher return (Sharmin, 2015). Apart from nutritional importance, it helps to employment generation, increase income and reduce poverty in developing countries like Bangladesh (Mitra & Yonus, 2018; SOFA team *et al.*, 2011; Weinberger & Genova, 2005). Vegetable production has experienced tremendous growth in last 40 years in Bangladesh. Winter vegetables of Bangladesh are tomato, water gourd, cauliflower, cabbage, rabi brinjal, rabi pumpkin, radish, bean, green spinach etc. Supply of vegetables increases in a large extent in the winter season. Surplus vegetables in winter reduces the market price and farmer's faces economic loss. Government may decide to export surplus vegetables after meeting domestic requirements or they can store surplus vegetables to reduce economic loss. Government or policy makers can take these decisions based on the growth and trend of winter vegetables production in Bangladesh. There are several studies on the growth and trend of crop production in the world but very few works on winter vegetables. Akhter *et al*. (2016) analyzed growth and trend in area, production and yield of major crops of Bangladesh and showed that area, production and yield of tea, pulse, rape and mustard increased. Fatima *et al*. (2015) examined the trends in wholesale prices of onion and potato in the major markets (Lahore, Hyderabad, Peshawar and Quetta) of Pakistan and found increasing prices of these two essential household items will be difficult to manage by the consumers. Abbasi *et al*. (2015) studied on the price trends of rice and wheat during different periods in Pakistan. Malhi & Kiran (2015) analyzed the trends in area, production and yield of important crops in India and got the variations in area, production and yield of the selected crops. Abid *et al*. (2014) analyzed growth and trend in area, production and yield of major crops of Khyber Pakhtunkhwa and found area, production and yield of maize was increased while area, production and yield of wheat was decreased over the time. Abid *et al*. (2014) found that forecast values of both area and production of maize depicted decreasing trend. The turn down in the area of maize may be due to the shifting of maize area to other Kharif crops. Weinberger and Lumpkin (2005) concluded that expansion of horticultural crops has exceeded the once dominating rice, wheat and maize throughout the world. It is evident that there is no work on trend and growth of winter vegetables in Bangladesh. Therefore, this study assesses the growth and trend of winter vegetables in Bangladesh. Most cultivated winter vegetables such as tomato, water gourd, cauliflower, cabbage, *rabi* brinjal, *rabi* pumpkin, radish, bean, green spinach are considered for this study.

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Materials and Methods

Data

A time series data from 1986–87 to 2015–16(30 years) regarding the area, production and yield of major winter vegetables (tomato, *rabi* brinjal, *rabi* pumpkin, water gourd, cauliflower, cabbage, radish, bean, green spinach) were collected from Bangladesh Bureau of Statistics (BBS) and year book of agricultural statistics.

Analytical technique

Semi-log trend function was used to find out the trend and estimate the growth rate of area, production and yield of major winter vegetables of Bangladesh. Wald test shows that including variables in quadratic function doesn't create any improvement to fit of the model. So, linear function is appropriate for this analysis. The model is given below:

$$\ln Z = \beta_0 + \beta_1 X + e$$

Where *Z* = dependent variable (area, yield and production); *X* = time variable; β_1= coefficient of trend; *ln*= natural logarithm; and *e* = error term. Here, the coefficient of trend (β_1) measures the constant proportional or relative change in Z for a given absolute change in the value of the regressor X.

$$\beta_1 = \frac{\text{Relative change in regressand}}{\text{Absolute change in regressor}}$$

If 100 multiply the relative change in Z, give the percentage change, or the growth rate, in Z for an absolute change in X, the regressor. That is, 100 times $\beta_1$gives the growth rate in Z; 100 times β_1 is known in the literature as the semi-elasticity of Z with respect to X and gives the instantaneous (at a point in time) rate of growth, to find out the compound (over a period of time) rate of growth, the following formula was applied (Abid *et al*. 2014).

$$\beta_1 = \ln (1+ r)$$

Whereβ_1= Instantaneous rate of growth; ln =Natural logarithm; r = Compound rate of growth. Hence taking antilog of β_1, subtract 1from it and multiply the difference by 100, would give compound rate of growth.

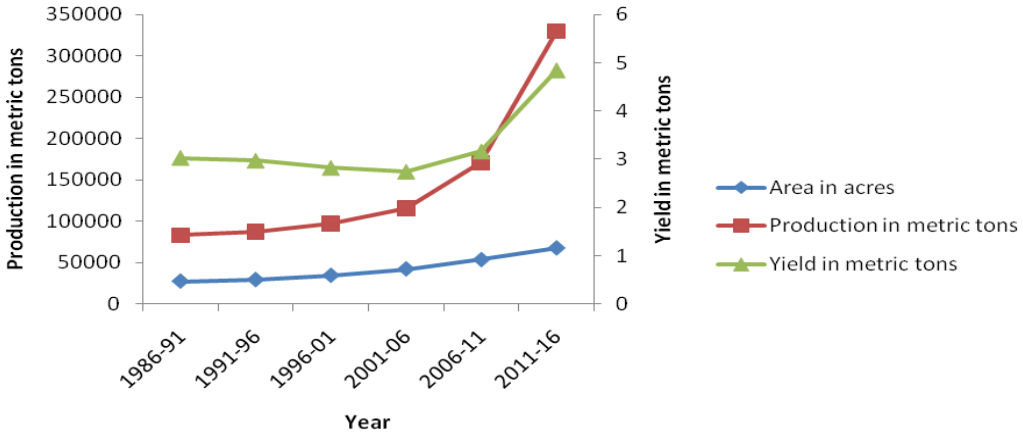
Results and Discussion

The most significant winter vegetables of Bangladesh are tomato, water gourd, cauliflower, cabbage, rabi brinjal, rabi pumpkin, radish, bean and green spinach. Although supply of these vegetables increases in winter season, these vegetables are also available in the market in summer season because of technological improvement. Trend and growth of winter vegetables in Bangladesh are described as follows:

Tomato

Tomato (*Lycopersicon esculentum* Mill) is one of the most important and popular vegetables in Bangladesh. It is cultivated in almost all home gardens and also in the field for its adaptability to wide range of soil and climate in Bangladesh. The best growing areas of tomato in Bangladesh are Chittagong, Comilla and Rajshahi (Hossain and Abdulla, 2015). Recent statistics show that tomato was grown in 67535 acres of land and total production was approximately 368121 metric tons in 2015–2016 (BBS, 2016). Thus the average yield of tomato was 4.45 metric tons acres^{-1}. Trend and Rate of Growth of Tomato in Bangladesh are given below.

Fig. 1 indicates that during 1986–91, the average area under tomato in Bangladesh was 27385.8 acres as compared to 67606.4 acres during 2011-16, which shows that area of tomato increased over time. The average production of tomato during 1986–91 to 2011–16 was increased from 83084.8 to 329608.6 metric tones due to the corresponding increase in per acres yield of tomato in Bangladesh. The results of semi-log model for area, production and yield of tomato during 1986–2016 were presented in Table 1. The results of F values show that the models were significant for area, production and yield of tomato in Bangladesh. It was revealed from the results that trend co-efficient for tomato area, production and yield was positive. The positive sign of compound growth rate shows that area, production and yield of tomato was increasing at a rate of 3.60 percent, 5.60 percent and 2.00 percent per annum, respectively. The most probable reason of this result is that farmers are adopting different local high yielding varieties of tomato such as BINA tomato- 2, BINA tomato- 3, BINA tomato- 4, BARI F1 Tomato-4 and BARI F1 Tomato-5. Besides these, farmers were using different exotic high yielding varieties like Lali, Nayak, Delta, Mintoo super and Success (Mitra & Yonus, 2018).



Source: Year book of agricultural statistics (1990–2016)

Fig 1. Trend and Rate of Growth of Tomato in Bangladesh (1986–2016)

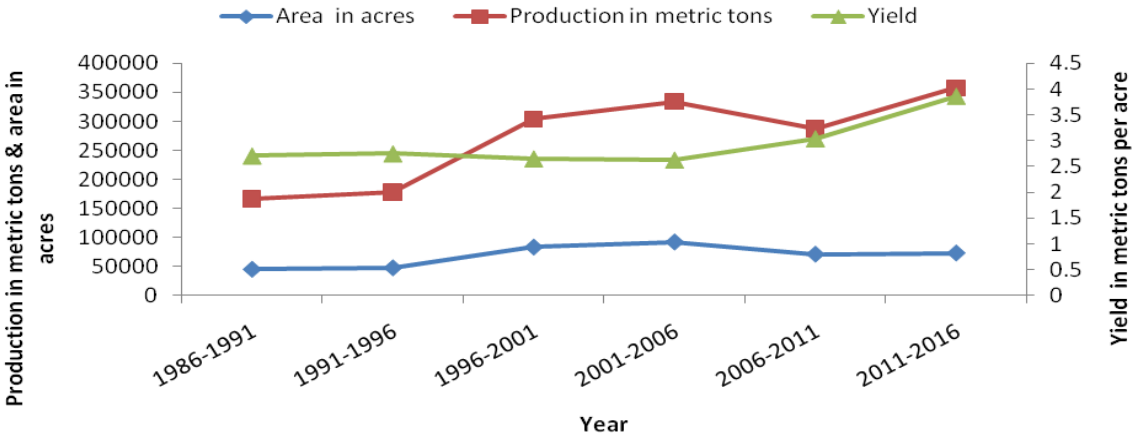
Table 1. Trend and rate of growth in area, production and yield of tomato in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	7079.51***	1191.05***	16.01***
Trend coefficient	0.03	0.05	0.02
t-statistic	12.82***	4.84***	2.12***
Instantaneous growth rate (%)	3.63	5.53	2.41
Compound growth rate (%)	3.60	5.60	2.00

***Significant at 1 percent level of significance

Rabi brinjal

Rabi Brinjal (*Solanum melongena*) is an important vegetable for its commercial and nutritional value in the world as well as in Bangladesh. It consists of almost 92.7 percent of water and is superior in terms of fiber, folic acid, manganese, thiamin, vitamin B6, magnesium and potassium contents to that of most other vegetables. (Rahman *et al*., 2016). The best growing areas of rabi brinjal in Bangladesh are Rajshahi, Sirajganj, Jamalpur, Jessore (BBS, 2016). It occupied 78458 acres of land with the total production of 340150 metric tons in Bangladesh (BBS, 2016). Trend and Rate of Growth of rabi brinjal in Bangladesh are given below.



Source: Year book of agricultural statistics (1990–2016)

Fig. 2. Trend and Rate of Growth of *Rabi* brinjal in Bangladesh (1986–2016)

In 1986–91, the average area under *rabi* brinjal was 44880 acres which increased to 73177.40 acres in 2011–16 and average production increased from 121741.80 metric tons in 1986–91 to 284290.40 metric tons in 2011-16, while the yield of *rabi* brinjal increased from 2.71 to 3.86 metric tons per acres during the same period (Fig. 2). The results of semi-log model for area, production and yield of *rabi* brinjal were presented in Table 2. It was revealed from the table that trend co-efficient for *rabi* brinjal production, yield and area was positive. The value of t-statistic of trend co-efficient for area, production and yield was also significant at 1% and 5% level of significance, respectively. The positive sign of compound growth rate shows that production, yield and area of *rabi* brinjal was increasing at a rate of 3.50 percent, 1.50 percent and 2.10 percent per annum, respectively. Productivity is increasing rapidly because of area and yield growth of rabi brinjal. Farmers have received training and extension services that will assist them to learn modern farming techniques. Besides training and extension services, farmer are adopting different variety like BARI Begun-1, BARI Begun-2 and BARI Hybrid Brinjal-4 (Digital Herbarium,2015) which are high yielding varieties of Bangladesh that helps to increase productivity.

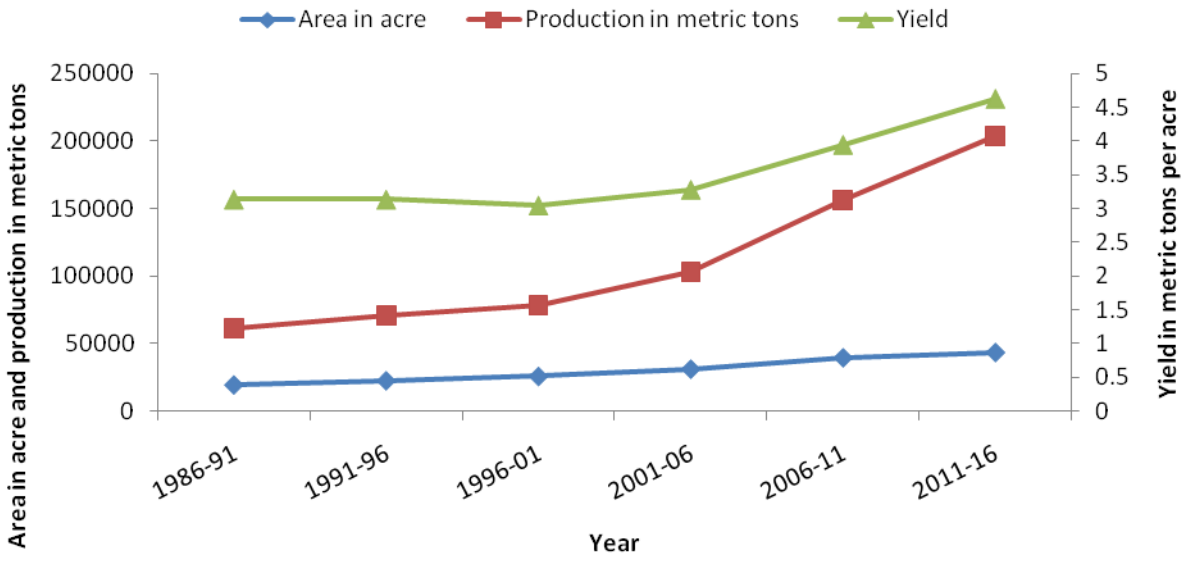
Table 2. Trend and rate of growth in area, production and yield of *rabi* brinjal in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	715.30**	933.91***	31.37***
Trend coefficient	0.021	0.035	0.015
t-statistic	1.92**	4.33***	2.60***
Instantaneous growth rate (%)	2.16	3.53	1.59
Compound growth rate (%)	2.10	3.50	1.50

***Significant at 1 percent **Significant at 5 percent level of significance

Cauliflower

Cauliflower (*Brassica oleracea* L**.** var**.** *botrytis*) is grown mainly as Rabi crop during winter. The production of vegetables including cauliflower is increasing day by day in Bangladesh. Among all the vegetables produced in the country, cauliflower dominates a major share in terms of total cropping area and production. It grows in all the districts of Bangladesh but plenty of cauliflower is produced in the region of Dhaka, Jessore, Rajshahi, Rangpur, Tangail and Kustia (BBS, 2016). It occupied 47749 acres of land with the total production of 268484 metric tons in Bangladesh (BBS, 2016). Trend and Rate of Growth of cauliflower in Bangladesh are given below.



Source: Year book of agricultural statistics (1990–2016)

Fig. 3. Trend and Rate of Growth of Cauliflower in Bangladesh (1986–2016)

Fig. 3 indicates that cauliflower was grown in Bangladesh in 1986-91 on an average area of 19553 acres with average production of 61448 metric tons and yield was 3.14 metric tons per acres. In the recent years 2011–16, the cauliflower area, production and yield increased to 43470.80 acres with an annual production of 203805.40 metric tons and yield 4.62 metric tons per acres. The results of semi-log model for average area, average production and yield of cauliflower were presented in Table 3. It was revealed from the table that trend co-efficient for cauliflower production, yield and area was positive. The value of t-statistic of trend co-efficient for area, production and yield was also significant at 1% level of significance, respectively. The positive sign of compound growth rate shows that production, yield and area of cauliflower was increasing at a rate of 5.00 percent, 1.70 percent and 3.00 percent per annum, respectively. Production of cauliflower was increasing rapidly because of area growth. Cauliflower is exported in different countries after meeting the domestic market and farmers can sell cauliflower at better price. It has encouraged the farmers to increase their farm area. In addition, yield is increasing because of new technology adoption and different varieties of cauliflower are kartica, patnai while late varieties are white mountain, BARI Fulkopi-1, BARI Fulopi-2 are very common to farmer (Digital Herbarium, 2015).

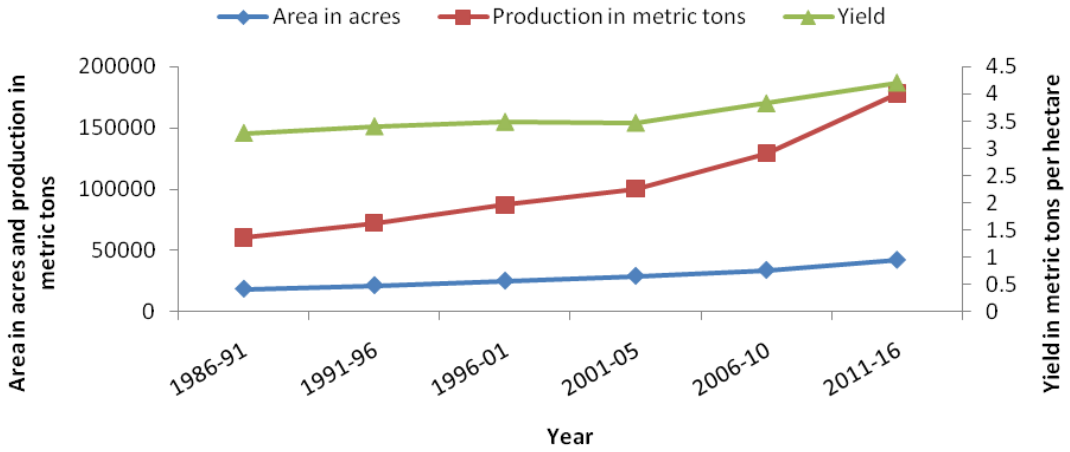
Table 3. Trend and rate of growth in area, production and yield of Cauliflower in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	8617.61***	1842.47***	37.59***
Trend coefficient	0.03	0.05	0.01
t-statistic	17.68***	7.76***	3.15***
Instantaneous growth rate (%)	3.34	5.06	1.78
Compound growth rate (%)	3.00	5.00	1.70

***Significant at 1 percent level of significance

Water Gourd

Water gourd (*Lagenaria vulgaris)* is a popular winter vegetables crop. This crop is sown form August to December and harvested from November to June. It grows in all the districts of Bangladesh but plenty of water gourd are produced in the region of Dhaka, Netraona, Gazipur, Comilla, Mymensingh, Chittagong (BBS, 2016). Recent statistics show that it was grown in 45784 acres of land and total production was approximately 218123 metric tons in 2015-2016 (BBS, 2016). Trend and Rate of Growth of water gourd in Bangladesh are given below.



Source: Year book of agricultural statistics (1990-2016)

Fig. 4. Trend and Rate of Growth of water gourd in Bangladesh (1986–2016)

The average area under water gourd in Bangladesh was increased from 18386.6 acres to 42090 acres during 1986 to 2016. The average production of water gourd during the same period was also increased from 60321 metric tons to 178022.60 metric tons due to the corresponding increase in area. The result of F static shows that the models were significant for area, production and yield of water gourd. The trend coefficient of area, production and yield was positive. Trend co-efficient for area, production and yield of water gourd was increasing at a rate of 3.32 percent, 4.77 percent and 1.26 percent per annum, respectively. The positive sign of compound growth rate shows that area, production and yield of water gourd was increased over the time. Whereas, the compound growth rate in area 3.30 percent, production 4.80 percent and yield 1.20 percent were calculated, respectively. Production is increasing because farmers cultivate different varieties of water gourd like BARI Lau-1 (1996), BARI Lau-2 (2006), BARI Lau-3 (2006), Khetlau and Hazari etc (Digital Herbarium, 2015).Training and extension services of government officials and NGO's help to increase water gourd production and yield.

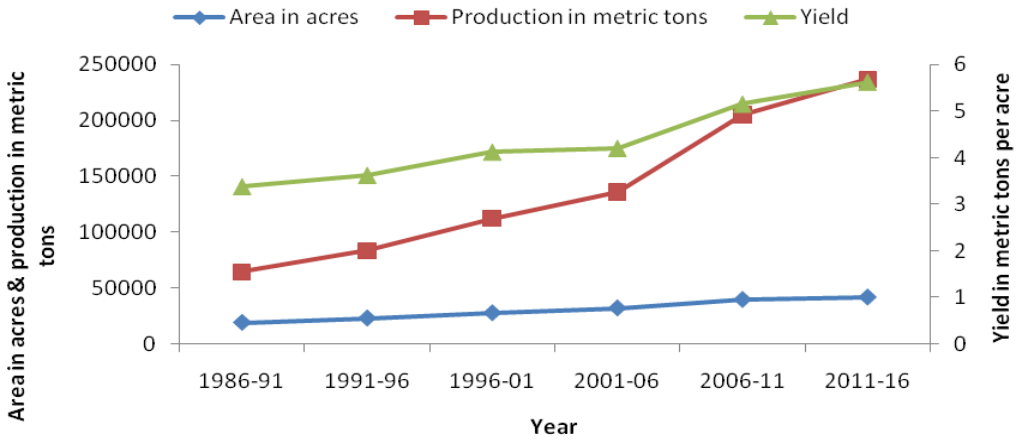
Table 4. Trend and rate of growth in area, production and yield of water gourd in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	18219.67***	6721.25***	155.81***
Trend coefficient	0.033	0.047	0.012
t-statistic	25.15***	10.21***	3.90***
Instantaneous growth rate (%)	3.32	4.77	1.26
Compound growth rate (%)	3.30	4.80	1.20

***Significant at 1 percent level of significance

Cabbage

Cabbage (*Brassica oleracea* L. var. capitata) is an important and nutritious leafy vegetable for winter season in Bangladesh. It is identified as one of the top twenty vegetables as well as an important source of food globally (FAO, 1988). Nutritionally, it contains vitamin A, B, C, E, and mineral such as iron, potassium, zinc, etc. It grows in many areas of Bangladesh like Chandpur, Comilla, Gazipur, Mymensing and Jessore etc (BBS, 2016). Trend and Rate of Growth of Cabbage in Bangladesh are given below.



Source: Year book of agricultural statistics (1990-2016)

Fig. 5. Trend and Rate of Growth of Cabbage in Bangladesh (1986-2016)

Fig. 5 indicates that during 1986-91, the average area under cabbage in Bangladesh was 18963.20 acres as compared to 41907.60 acres during 2011-16, which shows that area of cabbage increased over time. The average production of cabbage 1986-91 to 2011-16 was increased from 64208 tons to 236968.60 tons due to the corresponding increase in per hectare yield. The semi-log model was run for cabbage area, production and yield of Bangladesh and the results shows that the models were significant for area, production and yield of cabbage. The trend co-efficient of area, production and yield was positive. The positive sign of compound growth rate shows that area, production and yield of cabbage was increased over the time. Annual percentage growth was increased at the rate of 3.20 percent in area, while production and yield increased per year at the rate of 5.10 percent and 1.70 percent, respectively. Production is ever-increasing because farmers are adopting improve production technology and different varieties like provati and agradut are two high yielding varieties of cabbage that are released by BARI which are now commonly used production (Digital Herbarium,2015).

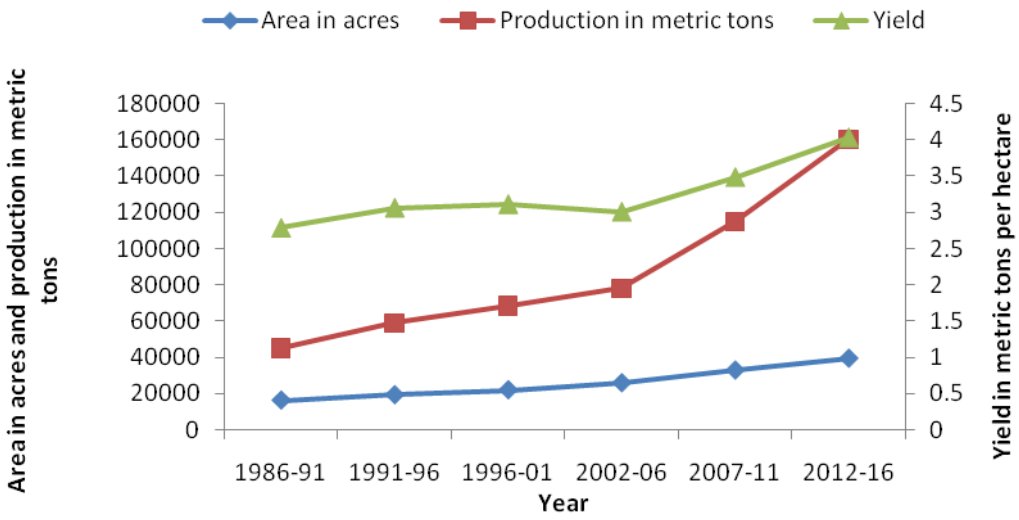
Table 5. Trend and rate of growth in area, production and yield of cabbage in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	14677.24***	27.75***	3.43**
Trend coefficient	0.0320	0.0500	0.0171
t-statistic	14.55***	5.27***	1.85**
Instantaneous growth rate (%)	3.20	5.00	1.71
Compound growth rate (%)	3.20	5.10	1.70

***Significant at 1 percent level of significance

Rabi Pumpkin

The production of vegetables including rabi pumpkin (*Cucurbita maxima)* is increasing day by day in Bangladesh. This vegetable can contribute potentiality to solve malnutrition problem of Bangladesh to certain extent particularly of the vulnerable groups in respect of vitamin A requirement. (*Hoque et al., 2015).* It grows in all the districts of Bangladesh but plenty of rabi pumpkins are produced in the region of Comilla, Mymensing, Kishorganj, Chittagong, and Dhaka (BBS, 2016). It occupied 42636 acres of land with the total production of 186112 metric tons in Bangladesh in 2015-16 (BBS, 2016). Trend and Rate of Growth of rabi pumpkin in Bangladesh are given below.



Source: Year book of agricultural statistics (1990–2016)

Fig. 6. Trend and Rate of Growth of Rabi pumpkin in Bangladesh (1986–2016)

The average area under rabi pumpkin in Bangladesh was increased from 16187.60 acres to 39545.40 acres during 1986-91 to 2012-16. The average production of rabi pumpkin during the same period was also increased from 45071.20 metric tons to 160173 metric tons due to the corresponding increase in yield. The semi-log model was run for rabi pumpkin area, production and yield of Bangladesh and the results shows that the models were significant for area, production and yield of rabi pumpkin. The trend coefficient of area, production and yield was positive. The positive sign of compound growth rate shows that area, production and yield of rabi pumpkin was increased over the time. Annual percentage growth was increased at the rate of 3.60 percent in area, while production and yield increased per year at the rate of 4.50 percent and 0.90 percent, respectively. Production of rabi pumpkin mainly increases due to increase of its area of production. It is very versatile in their uses for cooking and has an advantage over other vegetables as the fruit can be stored for up to 6 months before being consumed. So, farmers are more interested to produce it. Now farmers use different varieties of rabi pumpkin like BARI mistikumra-1 and BARI mistikumra-2 in winter season, both were developed in 2007 (Digital Herbarium, 2015) and different extension services and training facility assist the farmers to increase the production and yield of rabi pumpkin.

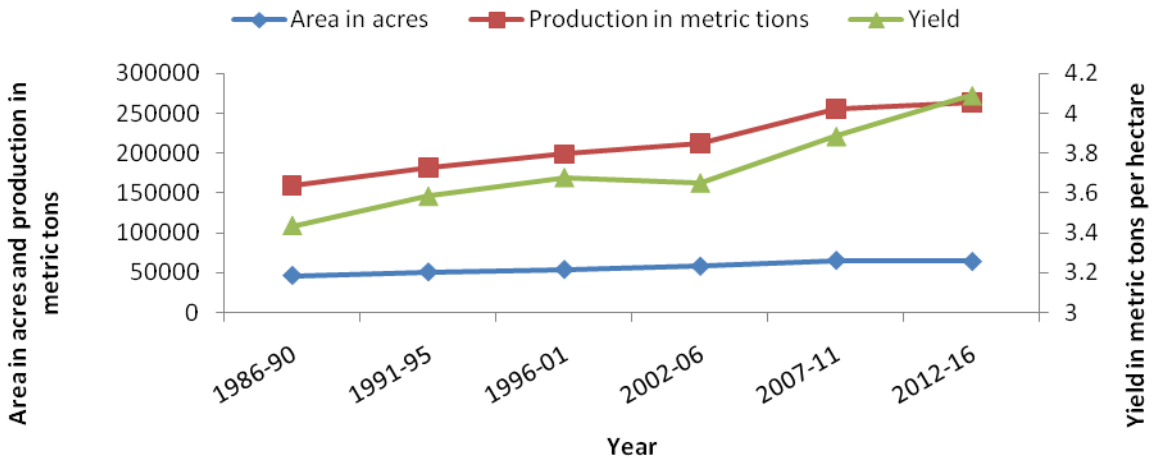
Table 6. Trend and rate of growth in area, production and yield of rabi pumpkin in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	19941.93***	23.61***	0.99*
Trend coefficient	0.0362	0.0449	0.00916
t-statistic	23.77***	4.86***	0.99*
Instantaneous growth rate (%)	3.62	4.49	0.916
Compound growth rate (%)	3.60	4.50	0.90

***Significant at 1 percent *Significant at 10 percent level of significance

Radish

Considering the area and production radish (*Raphanus sativus* L.) stands as one of the major vegetables crop of Bangladesh .it is mainly a winter vegetable crop. It is a good source of protein, carbohydrate, Ca, K, P and ascorbic acid (Larry, 1977). It grows in all the districts of Bangladesh but plenty of radish are produced in the region of Noakhali, Mymensingh, Comilla, Kishorganj, Tangail. Recent statistics show that tomato was grown in 65139 acres of land and total production was approximately 280871 metric tons in 2015-2016 (BBS, 2016). Trend and Rate of Growth of Radish in Bangladesh are given below.



Source: Year book of agricultural statistics (1990-2016)

Fig. 7. Trend and Rate of Growth of Radish in Bangladesh (1986-2016)

Fig. 7 indicates that radish was grown in Bangladesh in 1986-90 on an average area of 46392.6 acres with average production of 159414.40 metric tons and yield was 3.43 metric tons per acres. In the recent year 2012-16 the radish average area, average production and yield were increased to 64336 acres with an annual production of 263232.20 metric tons and yield 4.09 metric tons per acres. The results of semi-log model for area, production and yield of radish during 1986 to 2016 were presented in Table 7. The results of F-static show that the models were significant for area, production and yield of radish in Bangladesh. It was revealed from the results that trend co-efficient for radish area, production and yield was positive. The positive sign of compound growth rate shows that area, production and yield of radish was increasing at a rate of 1.40 percent, 2.10 percent and 0.70 percent per annum, respectively. Productivity of radish increases because farmers use different new varieties like BARI Mula-1, pinky, durti and BARI mula-4 are high yielding variety of Bangladesh (Digital Herbarium, 2015) and new technologies which helps their to get maximum return production.

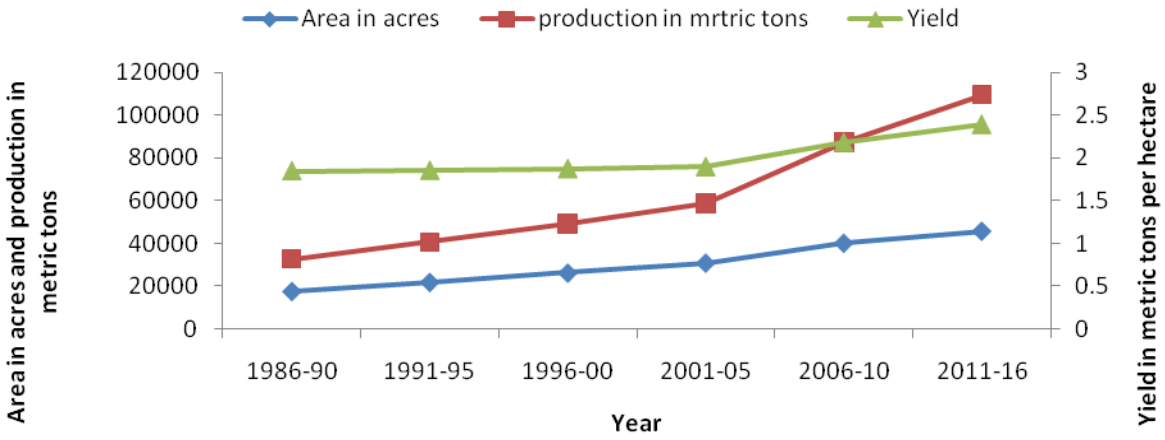
Table 7. Trend and rate of growth in area, production and yield of radish in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	25292.51***	19622.54***	705.62***
Trend coefficient	0.0147	0.0213	0.0070
t-statistic	7.96***	13.15***	6.36***
Instantaneous growth rate (%)	1.47	2.13	0.70
Compound growth rate (%)	1.40	2.10	0.70

***Significant at 1 percent level of significance

Bean

In Bangladesh total land area under bean cultivation is 49923 acres and the production is 128676 metric tons during 2015-16 (BBS,2016).Though country bean can be produced all over Bangladesh, the districts Chittagong, Comilla, Noakhali and Dhaka were the intensive bean producing areas. The Pabna district ranked the highest in respect of production per unit area (Islam and Karim, 1997).



Source: Year book of agricultural statistics (1990–2016)

Fig. 8. Trend and Rate of Growth of bean in Bangladesh (1986–2016)

The average area under bean in Bangladesh was increased from 17712.80 acres to 45714.60 acres during 1986-90 to 2011–16. The average production of bean during the same period was also increased from 32724.40 metric tons to 109658.80 metric tons due to the corresponding increase in yield. The results of semi-log model for area, production and yield of bean were presented in Table 8. The results of F statistic show that the models were significant for area, production and yield of bean. It was revealed from the table that trend co-efficient for bean area, production and yield is positive. The positive sign of compound growth rate shows that area, production and yield of bean was increasing at a rate of 3.80 percent, 4.90 percent and 1.00 percent per annum, respectively. Production of bean was increased because of area growth. It is one of the main exportable vegetables of Bangladesh which encourage the farmers to increase production. Different high yielding variety like BARI JAR Bean 1 and BARI Sheem 1 are commonly used by farmers to increase yield of bean (Digital Herbarium, 2015).

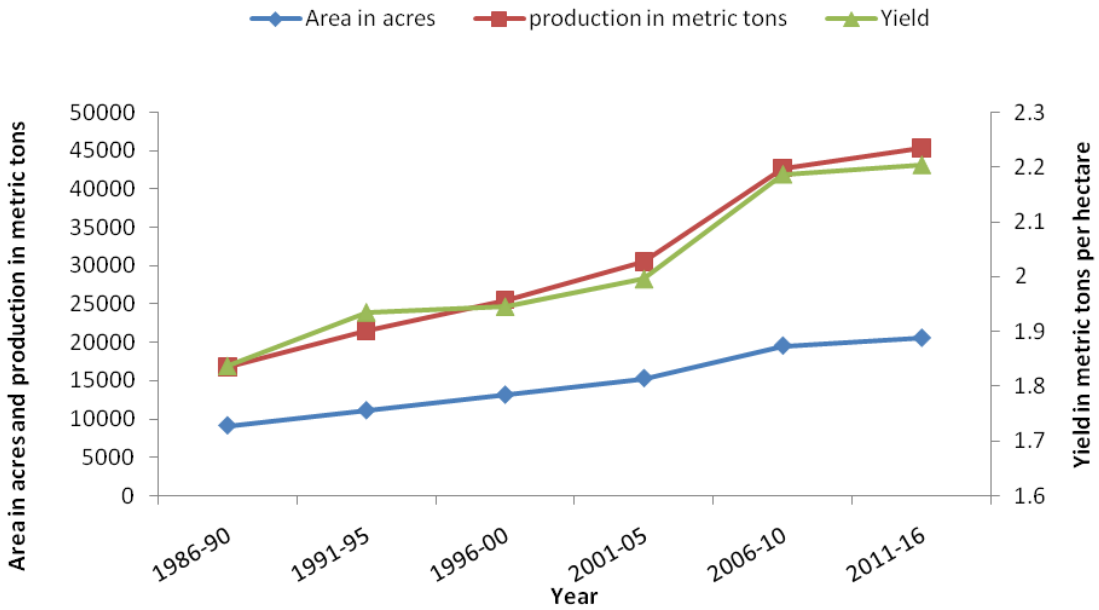
Table 8. Trend and rate of growth in area, production and yield of bean in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	16145.13***	5375.97***	47.54***
Trend coefficient	0.0384	0.0492	0.0109
t-statistic	28.70***	14.39***	3.66***
Instantaneous growth rate (%)	3.84	4.92	1.09
Compound growth rate (%)	3.80	4.90	1.00

***Significant at 1 percent level of significance

Green spinach

Green spinach (*Spinacia oleracea*) is a popular winter vegetables crop. It grows in all the districts of Bangladesh such as Khulna, Sherpur, Netraona, Rajshahi, Mymensingh, (BBS, 2016). Trend and Rate of Growth of green spinach in Bangladesh are given below.



Source: Year book of agricultural statistics (1990–2016)

Fig. 9. Trend and Rate of Growth of green spinach in Bangladesh (1986–2016)

Fig. 9 indicates that green spinach was grown in Bangladesh in 1986–90 on an average area of 9123.40 acres with average production of 16766.40 metric tons and yield was 1.83 metric tons per acres. In the recent year 2012–16 the green spinach average area, production and yield were increased to 20541 acres with an annual production of 45309.4 metric tons and yield 2.20 metric tons per acres. The results of semi-log model for area, production and yield of green spinach were presented in Table 9. It was revealed from the table that trend co-efficient for green spinach production, yield and area was positive. The value of t-statistic of trend co-efficient for area, production and yield was also significant at 1% level of significance, respectively. The positive sign of compound growth rate shows that production, yield and area of green spinach was increasing at a rate of 4.20 percent, 0.70 percent and 3.40 percent per annum, respectively. Production of green spinach is increasing because of area growth. Moreover, training and extension services help to increase productivity and yield of green spinach.

Table 9. Trend and rate of growth in area, production and yield of green spinach in Bangladesh, 1986–2016

Particulars	Area	Production	Yield
F-statistic	12651.26***	7672.77***	87.47***
Trend coefficient	0.0341	0.0418	0.0075
t-statistic	14.38***	15.89***	7.74***
Instantaneous growth rate (%)	3.41	4.18	0.75
Compound growth rate (%)	3.40	4.20	0.70

***Significant at 1 percent level of significance

Conclusion and policy implications

Production, yield and area of winter vegetables in Bangladesh had experienced significant growth. Among different vegetables, production growth of tomato, cabbage and cauliflower were the highest. Production of these vegetables increased because of increasing yield and farm area. Moreover, vegetable farming was commercializing day by day. It enhanced the use of new variety and cultivation techniques. Adoption of new variety helps to increase vegetables yield. In addition, yield growth of radish and green spinach was much lower than other winter vegetables. Probably, low market price of radish in winter was the reason of small yield growth.

Government can attempt to raise export of tomato, cauliflower and cabbage. Newly introduced variety and cultivation techniques help to increase yield, production and export of all vegetables. Therefore, storage facility and surplus vegetables export increase income and reduce economic loss of farmers.

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Appendix

Average area, production and yield of different vegetables are given below

1. Trend and rate of growth in area, production and yield tomato in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-91	27385.8	83084.8	3.03
1991-96	29210	86955	2.97
1996-01	34390	96951	2.82
2001-06	42179	115773	2.74
2006-11	53407	170677	3.16
2011-16	67606.4	329608.6	4.84

Source: Year book of agricultural statistics

2. Trend and rate of growth in area, production and yield rabi brinjal in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-1991	44880	121741.8	2.71
1991-1996	47432	130464	2.75
1996-2001	83417	220311	2.65
2001-2006	92214	241841	2.63
2006-2011	71178.4	216570.6	3.04
2011-2016	73177.4	284290.4	3.86

Source: Year book of agricultural statistics

3. Trend and rate of growth in area, production and yield cauliflower in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-91	19553	61448	3.14
1991-96	22585	70879	3.13
1996-01	25790	78729	3.05
2001-06	31164	103265	3.28
2006-11	39557.4	156238.6	3.94
2011-16	43470.8	203805.4	4.62

Source: Year book of agricultural statistics

4. Trend and rate of growth in area, production and yield water gourd in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-91	18386.6	60321	3.27
1991-96	21300	72522	3.40
1996-01	25003	87148	3.48
2001-05	28932	100310	3.46
2006-10	33766.2	129289	3.82
2011-16	42090	178022.6	4.20

Source: Year book of agricultural statistics

5. Trend and rate of growth in area, production and yield cabbage in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-91	18963.2	64208	3.38
1991-96	22895	83347	3.62
1996-01	27688	112334	4.12
2001-06	32077	135724	4.20
2006-11	39768.4	205243.6	5.15
2011-16	41907.6	236968.6	5.63

Source: Year book of agricultural statistics

6. Trend and rate of growth in area, production and yield rabi pumpkin in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-91	16187.6	45071.2	2.78
1991-96	19193	58843	3.06
1996-01	21961	68219	3.11
2002-06	25865	78032	3.01
2007-11	32932.4	114869.8	3.48
2012-16	39545.4	160173	4.03

Source: Year book of agricultural statistics

7. Trend and rate of growth in area, production and yield radish in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-90	46392.6	159414.4	3.43
1991-95	50848	182278.8	3.58
1996-01	54056	198816	3.67
2002-06	58232	212710	3.65
2007-11	65692.2	255337.6	3.88
2012-16	64336	263232.4	4.09

Source: Year book of agricultural statistics

8. Trend and rate of growth in area, production and yield bean in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-90	17712.8	32724.4	1.84
1991-95	21917	40620	1.85
1996-00	26245	49095	1.87
2001-05	30884	58769	1.89
2006-10	40131.8	87515	2.18
2011-16	45714.6	109658.8	2.38

Source: Year book of agricultural statistics

9. Trend and rate of growth in area, production and yield green spinach in Bangladesh, 1986–2016

Year	Area in acres	Production metric tons	Yield (metric tons/ acres)
1986-90	9123.4	16766.4	1.83
1991-95	11090	21479	1.93
1996-00	13121	25529	1.94
2001-05	15286	30553	1.99
2006-10	19523.2	42715.4	2.18
2011-16	20541	45309.4	2.20

Source: Year book of agricultural statistics