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GROWTH AND INSTABILITY ANALYSIS OF LENTIL IN BANGLADESH

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Abstract

lentil stands out as a major contributor, essential not only for human nutrition but also for sustaining both human health and agricultural soil quality. A comprehensive investigation spanning four decades (1981-2020) was conducted to analyze growth and instability of lentil in Bangladesh using secondary data. Understanding these dynamics is crucial for enhancing agricultural resilience, food security, and sustainable practices to meet increasing demands and challenges precipitated by erratic weather patterns. The study divided the period into four sub-periods (1981-1990, 1991-2000, 2001-2010 & 2011-2020) and utilized statistical tools for analysis. The application of exponential growth functions facilitated the determination of growth rates, while the Cuddy-Della Valle index assessed instability. The analysis revealed that the production and yield of lentils had increased. The change in area and yield contributed respectively 41.7% and 55.5% to the changes in the mean production of lentils at the national level. Though the lentil's yields increased significantly, the rate of growth is slow and inadequate to meet our country's demand. The analysis also revealed that the area, production, and yield of lentils were not stable during the study period.

Keywords: Lentil, growth rate, instability, Bangladesh.

Introduction

Pulses hold significant importance within the agricultural landscape of Bangladesh, serving as essential and valuable sources of nutrition for human consumption (Das et al., 2016). Pulses play a vital role in agricultural and environmental sustainability through nitrogen fixation, carbon sequestration, and organic matter enrichment (Senanayake et al., 1987; Zapata et al., 1987; Sarker and Kumar, 2011). The congenial climatic conditions prevailing across Bangladesh facilitate the cultivation of diverse pulse varieties all over the country, making pulses, often referred to for low-income populations. Among the pulses, lentils are one of the oldest and most popular food legumes in Bangladesh. Lentil is cultivated during the winter (November-March.) in Bangladesh. It occupied 40.23% of the cultivation of pulse crops, getting the first position in Bangladesh (BBS, 2019). They are frequently mixed with rice to produce more complete proteins. It contains carbohydrates, mainly starches (55-65%); proteins, including essential amino acids (24-28%), and fat (1-4 %) (Rahman et al.,2012). Different studies (Miah et al., 2021; Sarker et al., 2020; Matin et al., 2018; Tithi and Barmon,

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2018) revealed that lentil production is profitable to farmers. Hence, it is cultivated in different parts of the country covering 146.03 thousand hectares of land and producing 185.50 thousand metric tons of seed per year with a productivity of 1.27 t/ha (BBS, 2022). but imported 455298.43 tons of lentils valued at 284.952 million USD in 2021 (FAO Stat, 2021).

Instability is a very important characteristic of agriculture. Since agriculture is dependent on weather conditions, the area, production, and yield of crops are subject to significant variations over time. Instability also exists in the area, production and yield of lentils. There has been a dearth of studies dealing with the growth and instability of lentils in Bangladesh. Hence, the present study was undertaken to analyze the growth and instability in the area, production, and yield of lentil along with the contributory factors affecting the growth and instability of lentil production. The findings of this study could provide useful guidelines for the relevant researchers, policymakers, and planners of the country. The specific objectives of this study were given below.

(i) To determine the growth rates of area, production, and yield of lentils in Bangladesh;

(ii) To measure the change and instability in area, production, and yield of lentils; and

(iii) To derive some policy guidelines for the development of lentils in Bangladesh.

Materials and Methods

The study was based on secondary data collected from various published sources. Times series data on the area, production, and yield of lentils for 40 years period from 1981 to 2020 were collected from different issues of the *Yearbook of Agricultural Statistics of Bangladesh*.

Various statistical measures were used to analyze the data to examine the nature of change, instability, and degree of relationship in area, production, and yield of lentils in Bangladesh.

***Trend analysis*:** Trend analysis aims to find out the extent and causes of instability of area and production of lentils over time. This information may lead research managers as well as policymakers to prepare appropriate policy documents for the improvement of lentils for the country. A simple line graph and bar diagram were used to show the trends in area, production, and yield of lentils in Bangladesh.

***Index number*:** The relative changes in area, production, and yield of lentils that occur within a specified timeframe can be quantified using an index number. At first, the entire study period is divided into four sub-periods such as: 1981-1990, 1991-2000, 2001-2010, and 2011-2020. The reason for the division was to know the changes that occurred in the area, production, and yield of lentils in every 10 years period. The average value of area, production, and yield of first 10 years sub-period (e.g. 1981-1990) provided the base information.

Annual growth rates: Growth rates are *the percent change of a variable over time*. It is important because it can help researchers and policymakers predict future growth. For simplicity and widely used even in the recent past (Das and Mishra 2020; Chaudhary et al., 2016) the compound growth rates of area, production, yield, and price of lentils were worked out by fitting an exponential function of the following type:

$$Y = ae^{bt} \quad \text{or } LnY = Lna + bt \text{ -- } (1)$$

Where, Y is the area/production/yield of lentil, 't' is the time in a year, and 'a' is the constant, e^b -1 be the compound growth rate which is expressed in percentage.

The component analysis model has been used to measure the relative contributions of area and yield toward the overall output change with regard to individual crops. The growth performance of the crops has been studied using this model by numerous researchers in the literature (Gupta and Saraswat, 1997; Singh and Ranjan, 1998; Siju and Kombairaju, 2001; Kakali and Basu, 2006).

$$\Delta P = A\circ\Delta Y + Y\circ\Delta A + \Delta A\,\Delta Y \text{------------------------ } (2)$$

Change in production = Yield effect + Area effect + Interaction effect.

Thus, the total change in production is attributed due to area and yield that can be decomposed into three effects viz; yield, area and interaction effects.

Instability index: Instability means the quality or state of being unstable or lack of stability. Agricultural instability can be measured by different methods, such as the coefficient of variation (CV), dispersion, Cuddy Della Valle Index (CDI), Coppock Instability index, etc. The present study applied the Cuddy and Valle (1978) Index for examining the nature and degree of instability in the area, production, and yield of lentils in Bangladesh. The use of CV as a measure to show the instability in any time series data has some limitations. It does not explain properly the trend component inherent in the time series data. If the time series data exhibit any trend, the variation measured by CV can be overestimated, i.e. the region which has growing production at a constant rate will score high in instability of production if the CV is applied for measuring instability. As against that, CDI first attempts to de-trend the CV by using the coefficient of determination (R^2). Thus it is a better measure to capture instability in agricultural production. A low value of this index indicates low instability in farm production and vice-versa. The estimable form of the equation is as follows:

$$CV_t = (\mathrm{CV})\times\sqrt{1-R^2} \text{ -- } (2)$$

Where CV_t is the coefficient of variation around the trend; CV is the coefficient of variation around the mean in percent; and R^2 is the coefficient of determination from time trend regression adjusted by the number of degrees of freedom.

$$\mathrm{CV} = \frac{Standard\ deviation}{Mean}\times 100$$

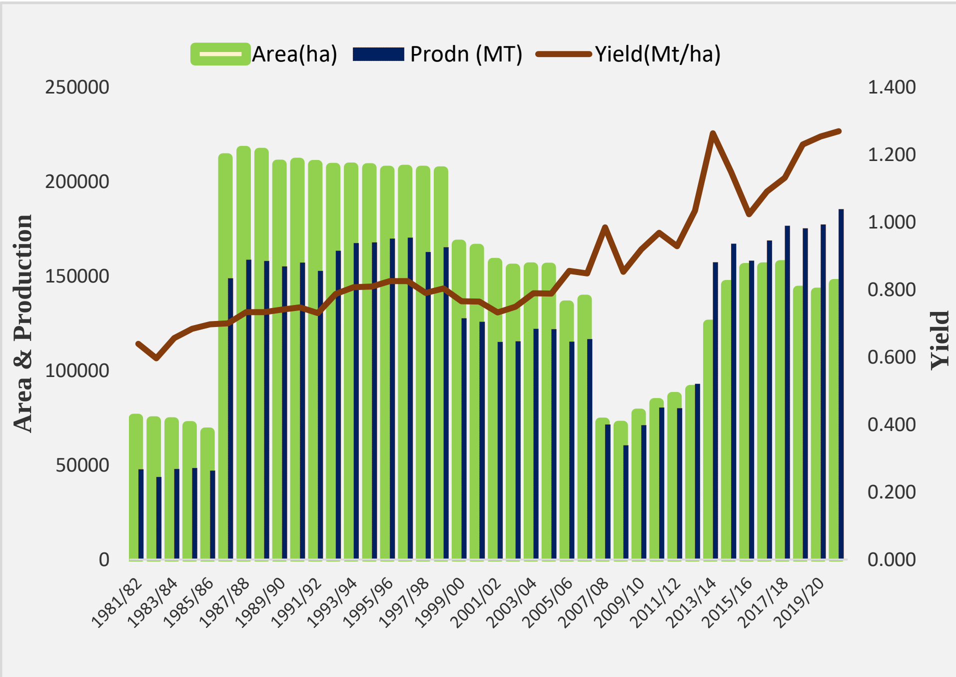
$$R^2 = 1 - \frac{Unexplained\ variation}{Total\ variation}$$

Results and Discussion

Trends of Area and Production of Lentil in Bangladesh

The area and production of lentils were found to fluctuate in nature, but the yield registered an increasing trend over the years. Figure 1 shows that the area and production of lentils for the period from 1981/82 to 1985/86 were very low compared to the succeeding years. Despite various positive sides, the crop faced competition in the recent past from cereals, particularly wheat and *Boro* rice, due to the expansion of irrigation facilities, and the availability of high-yielding varieties (Sarker et al., 1989). Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agricultural (BINA) disseminated some improved lentil varieties and popularized them through different projects. The inclusion of these improved varieties in the cropping patterns replacing local varieties might be the cause of the increase in area, production, and yield of lentils. Therefore, both area and production of lentils were very high for the period of 1986/87-1998/99. Again in the period 1999/00-2008/09, the overall area and production of lentils in the country were found decreasing trend which might be due to susceptible crops and less remunerative in production. After that period the area, production, and yield of lentils further increased steadily from 2009/10 to 2019/20.

Fig. 1. Trend of area, production, and yield of lentil during 1981/82-1999/20



Source: Using data from various issues of BBS

The overall indices reveal a substantial increase in both the area under cultivation and the production of lentils, indicating notable growth from the base period of 1981-1990 to the subsequent decade of 1991-2000 (Table 1). But the overall indices of area and production show a decreasing trend from 2001 to 2010. On the other hand, the productivity indices revealed an increasing trend during the period from 1981-1990 to 2011-2020. Despite the decrease in area, the per hectare yield of lentils has rise up in that period which was mainly due to the adoption of improved variety and management technologies.

Table 1. Index of area, production, and yield of lentil

Time Period	Area (%)	Production (%)	Yield (%)
1981-1990	100 (142345)	100 (101307)	100 (0.69)
1991-2000	139.6	155.4	114.1
2001-2010	84.1	97.8	122.5
2011-2020	94.3	152.0	164.1

Note: Figures within parentheses indicate 10 (ten) year average value of the base period. .

Source: Various issues of BBS

Annual Growth of Lentil Production The analysis of the overall annual growth rates over a period of 40 years (1981-2020) highlights a positive and significant growth in the production and yield of lentils. However, in contrast, the growth rate of cultivated area exhibited a non-significant negative trend during the same period (Table 2). The growth rates of different periods show that some growth rates registered in area and production were found positive and significant from 1981-1990 and 2011-2020. The period of 1991-2000 and 2001-2010 witnessed markedly adverse trends in both area and production growth rates, with values of (-2.27 & -2.2) and (-10.13 & -7.113), respectively. This decline can be attributed to a combination of factors, including delayed sowing, yield instability stemming from biotic and abiotic stresses, the heightened vulnerability of local cultivars to significant diseases, and the inherent low yield potential of local cultivars (Sarker et al., 2004). However, the growth rates of yield were positive and highly significant for all periods except the period 1991-2000. The highly significant growth rates of yield were mainly due to the adoption of improved lentil variety and technology. This indicates that more adoption of the modern varieties of lentil is needed in the farmers' fields.

Table 2. Annual growth rates of area, production and yield of lentil, 1981-2020

Time period	Area	Production	Yield
1981-1990	16.10***	18.34***	2.24***
1991-2000	-2.27***	-2.20*	0.08
2001-2010	-10.13***	-7.11***	3.02***
2011-2020	5.32**	7.77***	2.45**
1981-2020	-0.21	1.36**	1.57***

Note: ‘***’ ‘**’ and ‘*’ represent 1%, 5% and 10% level of significant

Sources of Growth of Lentil Production

Change in the mean area appeared to be the largest source of change in the mean production of lentil in all the periods. At the national level, changes in the mean area and yield were the main two sources of changes in lentil production in Bangladesh. The change in area and yield contributed respectively 41.7% and 55.5% to the changes in the mean production of lentils at the national level. This means that the positive change in production has been attributed to the positive change in area and yield (Table 3).

Table 3: Growth decomposition in the production of Lentil during 1981-2020

Time period	Effect (%)				
	Area (A)	Yield (Y)	Interaction	Residual	Total
	ΔA*Y	A*ΔY	ΔA*ΔY	ΔCOV(A,Y)	ΔQ
1981-1990	86.76	13.62	0.38	-0.76	100
1991-2000	111.60	-16.09	-4.50	8.99	100
2001-2010	167.15	-47.13	20.03	-40.05	100
2011-2020	69.90	33.38	3.28	-6.56	100
1981-2020	41.70	55.50	-2.78	5.58	100

Source: Author's calculation using BBS data of different years

Instability of Lentil Cultivation

The estimates of instability in the area, production, and yield of lentil are presented in Table 4. The instabilities of the lentil area (3.43%) and production (3.62%) at the national level were not so high, but the instability of production was a little bit higher than the area instability. On the other side, the instability related to productivity was about -48.68% during 1981-2020 meaning that lentil productivity was almost stable over the stipulated period.

Table 4: Instability indices for area, production and yield of lentil, 1981-2020

Time period	Instability (%)		
	Area (ha)	Production (t)	Yield (t/ha)
1981-1990	2.59	2.67	-7.79
1991-2000	0.52	0.79	-16.31
2001-2010	1.52	1.47	-26.82
2011-2020	1.25	1.48	61.44
1981-2020	3.43	3.62	-48.68

Source: Author's calculation using BBS data

Conclusions

During the study period (1981–2020), the trend analysis of lentils revealed a notable fluctuation in both their cultivation area and production levels. However, a more detailed examination of the last decade provides a distinct perspective, revealing a constant upward trajectory in both the cultivation area and production of lentil. This recent trend signifies a positive shift in lentil cultivation practices and management. This increase in yield can be attributed to the widespread adoption of improved varieties and management technologies. These advancements have likely played a crucial role in boosting the overall productivity of lentil cultivation and contributing to its upward trend in both area and production.

Sustainable agricultural performance hinges on the combination of a high growth rate and low production instability, a crucial consideration with profound implications for policymakers. In the context of this study, a comprehensive exploration of lentil production in Bangladesh has been undertaken, revealing noteworthy insights. The examination of lentil production growth underscores a positive and significant increase in both yield and production for lentil. However, it is important to note that this growth is modest in nature, indicating room for further advancement. Conversely, a contrasting trend emerges in the case of lentil cultivation area, with observed negative growth rates. This decline suggests a potential concern, suggesting the possibility of shrinking cultivable land or waning farmer interest in lentil cultivation. The inherent susceptibility of agricultural production to natural calamities is an enduring reality in Bangladesh, introducing a layer of instability. When scrutinizing the scope of instability in lentil cultivation, the national level showcases a comparatively lower degree of instability. This underlines the resilience of lentil cultivation in the face of natural fluctuations, offering a glimmer of stability within the broader agricultural landscape.

Recommendations

Based on the findings of this study, a number of recommendations can be made to promote sustainable growth in lentil production in Bangladesh. Firstly, agricultural scientists should develop more climate-friendly and high-yielding varieties of lentil to meet the increasing demand. Secondly, existing BARI-developed improved lentil varieties and technologies should be disseminated among farmers through pilot projects. Thirdly, research and policy support is needed to increase the acreage and yield of lentil which will help increase the per capita availability of lentil, reduce import dependence, and to some extent stabilize lentil prices. Finally, collaboration between government agencies, NGOs, and private sector stakeholders should be given priority for increasing the growth and stability of lentil in Bangladesh.

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