# YIELD GAP MINIMIZING STRATEGIES FOLLOWED BY TOMATO GROWERS OF BURICHANG UPAZILA UNDER CUMILLA DISTRICT

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# CERTIFICATE

This is to certify that the thesis entitled **"YIELD GAP MINIMIZING STRATEGIES FOLLOWED BY TOMATO GROWERS OF BURICHANG UPAZILA UNDER CUMILLA DISTRICT"** submitted to the Department of Agricultural Extension and Information System, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfillment of the requirements for the degree of Master of Science (M.S.) in Agricultural Extension, embodies the result of a piece of bona fide research work carried out by **MD. ABUL HASAN, Registration No. 19-10075** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by the Author.

Dated: ……

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DEDICATED

TO

MY BELOVED

PARENTS

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*The Author*

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## ABBREVIATIONS

| | |
|---|---|
| BBS | Bangladesh Bureau of Statistics |
| GDP | Gross Domestic Product |
| NGO | Secondary School Certificate |
| RAD | Regional Agronomic Diagnosis |
| BRRI | Bangladesh Rice Research Institute |
| BARC | Bangladesh Agricultural Research Council |
| OFRD | On Farm Research Division |
| PAR | Photosynthetic Active Radiation |
| FAO | Food and Agriculture Organization |
| SAU | Sher-e-Bangla Agricultural University |
| SPSS | Statistical Packages for Social Sciences |
| CI | Causes Index |
| FLDs | Front Line Demonstrations |
| DAE | Department of Agricultural Extension |
| ICM | Integrated Crop Management |
| IRRI | International Rice Research Institute |
| DAT | Days after Transplanting |
| HYV | High Yielding Variety |
| TSP | Triple Super Phosphate |
| IPM | Integrated Pest Management |

**YIELD GAP MINIMIZING STRATEGIES FOLLOWED BY TOMATO GROWERS OF BURICHANG UPAZILA UNDER CUMILLA DISTRICT**

**MD. ABUL HASAN**

## ABSTRACT

Tomato (*Solanum lycopersicum* L) is one of the major vegetable crops cultivated in Bangladesh, which plays a major role in supplementing the income of small and marginal farmers of Burichang upazila under Cumilla district. The objectives of this study were to describe the socio-economic profile of tomato growers; to determine the extent of tomato yield gap minimizing strategies by the growers; to explore the contributing relationship between the socio-economic profile of tomato growers with their yield gap minimizing strategies; and to identify the causes of tomato yield gap. The study was conducted with randomly selected 101 tomato growers in one union of Burichang upazila under Cumilla district. A pre-tested interview schedule was used to collect data from the respondents during 22$^{th}$ January to 21$^{th}$ February, 2021. Yield gap minimizing strategies of tomato cultivation was the dependent variable and it was measured on the basis of a five (5) point rating scale with 15 strategies were used. The majority (57.43%) of the tomato growers had medium tomato yield gap minimizing strategies compared to 26.73% of them having high tomato yield gap minimizing strategies and 15.84% having low yield gap minimizing strategies. Among 11 selected characteristics of the farmers 4 characteristics namely, yield gap of tomato cultivation, education, professional training experience and farmers' knowledge on tomato cultivation had significant contribution to their tomato yield gap minimizing strategies. According to Causes Index (CI), "early message of weather forecasting" ranked first followed by "inadequate extension service to support tomato production", "high cost of inputs (seed, fertilizer and pesticides)" and "pressure from middleman to sell produces at lower price." Education of the farmers had most significant contributing factor on their practice of tomato yield gap minimizing strategies. So it can be concluded that education increased knowledge and ability of farmers to understand and response to advance agricultural practices which drove them to adopt advance strategies to minimize tomato yield gap.

# CHAPTER I
# INTRODUCTION

## 1.1 General Background of the Study

Agriculture is the backbone of the economy of Bangladesh. The development of Bangladesh depends largely on the development of agriculture sector which contributes 13.35% of the GDP (BBS, 2021). About 70% of the total population live in rural areas depending directly or indirectly on agriculture for their livelihood. About 45.1% of the labor forces are employed in agriculture of which 42.47% are employed in the crop sector. In Bangladesh vegetables are grown in 2.63% of cultivable land (BBS, 2021).

One of the biggest challenges in agronomy is the determination and ranking of the major causes of yield gaps. Yield-gaps can be considered as the difference between the potential yield and the actual yields of farmers in a certain place and time of interest (Fermont et al., 2009; Van Ittersum et al., 2013, Lobell et al., 2009). The potential yield is the maximum possible yield that can be achieved in certain agro-ecological conditions and is defined by factors such as cultivar features, radiation, temperature and $CO_2$ (Van Ittersum and Rabbinge, 1997, Van Ittersum et al., 2013). Potential yield is a concept that can be quantified using crop growth models but in practice can be found only in very few cases, such as greenhouses in the Netherlands. Usually, however, maintaining potential growth conditions is technically and economically not feasible. Most farmers do not achieve the potential yield, but a much lower actual yield that is limited by water and nutrients, and reduced by weeds, pest, diseases and pollutants (Van Ittersum et al., 2013). In practice, not so much the theoretically potential yield, but yield levels derived from field experiments, or maximum yields achieved by farmers in a region may be used to define the yield gap (Lobell et al., 2009). The knowledge about the factors that contribute to yield-gaps in crops is essential for sustainable intensification of agriculture, which has the objective to increase both yield and environmental sustainability of crop production (Garnett et al., 2013). The challenge is to be able to identify which of the multiple factors influences the yield more, and to quantify the possible improvements.

Lobell et al., (2009) made a list of biophysical and socioeconomic factors that commonly affect crop growth and yields in farmers' fields (Table 1.1).

**Table 1.1 Common factors that contribute to yield losses in farmers' fields (Lobell et al., 2009)**

| |
|---|
| **Biophysical factors** |
| Nutrient deficiencies and imbalances<br>(nitrogen, phosphorus, potassium, zinc, and other essential nutrients) |
| Water stress |
| Flooding |
| Suboptimal planting (timing or density) |
| Soil problems<br>(salinity, alkalinity, acidity, iron, aluminium, or boron toxicities, compaction, and others) |
| Weed pressures |
| Insect damage |
| Diseases (head, stem, foliar, root) |
| Lodging (from wind, rain, snow, or hail) |
| Inferior seed quality |
| **Socioeconomic factors** |
| Profit maximization |
| Risk aversion |
| Inability to secure credit |
| Limited time devoted to activities |
| Lack of knowledge on best practices |

The challenge of determining limiting factors and quantifying improvements has been addressed already for a couple of decades under the name of regional agronomic diagnosis' (RAD) or yield-gap analysis (Doré et al., 2008 and Lobell et al., 2009). RAD is a methodological framework used in crop systems research to study the variations of yields at zone- or regional level by a crop systems approach, as well as a way to understand the relation between the production results and the farmers' practices. RAD bases its diagnosis on annual on-farm surveys, and environment and crop-yield build-up monitoring. The major goal of RAD is to identify and rank limiting factors for crop yield on the regional scale (Doré et al., 1997 and Doré et al., 2008).

Tomato is grown in winter months of Bangladesh as the temperature is congenial at that period of time for optimum growth and yield. But it has great potentiality to grow in summer also. Because of its palatability and vitamin content, its demand in general is growing day by day. Tomato is one of the essential vegetables for growth and maintenance of health of human beings. In the month of December to March varieties of tomatoes are available throughout Bangladesh. Our population is increasing day by day and so is the demand of tomato be it in domestic consumption or be it in other use. Tomato has a queer variety of uses like vegetables and other food items. It is tomato which makes the food palatable. It has high medicinal values because it contains vitamin C&A, calcium and iron.

Tomato is the most consumable vegetable crop after potato and sweet potato occupying the top of the list of canned vegetables and plays an important role in providing balanced nutrition. Its consumption quantity in recent years increased at an average rate of 3% annually (Nicola et al., 2009). At present 6.1% area of vegetables is under tomato cultivation, both in winter and summer (Anonymous, 2005). It is cultivated all over the country due to its adaptability to a wide range of soil and climate. The total area under tomato cultivation was 67,535 acres and the production was 368,121 MT at 2019-2020 in Bangladesh (BBS, 2017). However, the yield of the crop is very low compared to those obtained in some advanced country (Karim et al., 2009). To meet up local demand, Bangladesh Government has also been importing tomato from the neighboring countries. The government imported 9395.14 MT of tomato in exchange of 1503 million takas from foreign countries in the year 2000-2001 (Mohiuddin et al., 2007). Insect pests are an important threat to tomato production. In order to fight pests, farmers of Bangladesh heavily rely on pesticides. Pesticides can easily dissolve with water and that is why it pollutes the soil surface water and also contaminates ground water through infiltration and percolation. Besides, rain water also mixes with pesticides which pollute pond/canal/other water bodies and damage natural resources such as fish, beneficial insects, and micro-organisms. Their massive and frequent misuses have led to the problems viz.; resistance of pesticides, the resurgence of pests and residues as well as toxicity hazards to non-target animals. Bangladesh is not exceptional in this general trend of environmental degradation. Agriculture and environment have a close relationship and interact with each other in such a way that the health of agriculture depends on the proper functioning of environmental process and also upon respectful agriculture (Hoque et al., 2009). It needs to consider food safety issues so that it will be safer and healthier. Drawbacks of chemical pesticides emphasized the need to identify alternate eco-friendly methods to manage the pests of tomato. To rely fully on chemical control is not feasible in social, economic and environmental aspect. Therefore, an alternative strategy is needed to control pest in less expensive and environment friendly way. Hence, IPM practices are now being considered as the most appropriate one to control pest. Around the world, IPM has been widely adopted as a rational strategy to manage pests in crop cultivation. There are few studies examining the effectiveness of an IPM program on tomato cultivation. Rahman (2005) found that IPM farmers reduced the number of pesticide use application up to 89 percent and at the same yield increased to 10 percent. Razzaque et al., (2005) reported that IPM trained farmers reduced the number of pesticide application up to 88% while at the same yield increased to 9%.

## 1.2 Status of Tomato Production in Bangladesh

Tomato is one of the salient food items not only in Bangladesh but also in every country of the globe. Tomato production in Bangladesh is mainly a smallholder activity to provide income to the farming community and all others who are involved in its production and marketing. Tomato farming requires seed, land, labour, capital and fertilizers. The use of primitive technique is held responsible for the low production of tomato. Hence, the production of tomato demands an upto-date management system. We have to bear in mind that tomato production is vulnerable to bad weather particularly rain which may result in huge damage of crop. Tomato is mainly winter crop. But with the thrivement of the agro-sector, now-a-days, like many other crops, tomato is being grown more or less all the year round. Hence, the production as well as the use of tomato is on the increase across the country. Table 1.2 shows the Area and Production of tomato in Bangladesh from 2014-15 to 2018-19.

**Table 1.2 Tomato productions in Bangladesh**

| Year | Area ‘000, Acres | Production ‘000,M. tons | Per acre Yield (kg) |
|---|---|---|---|
| 2014-15 | 65 | 361 | 5289 |
| 2015-16 | 67 | 368 | 5451 |
| 2016-17 | 68 | 389 | 5686 |
| 2017-18 | 70 | 385 | 5539 |
| 2018-19 | 70 | 388 | 5562 |

Source: BBS, 2020

## 1.3 Statement of the Problem

In Bangladesh, yield gaps in vegetable and other agricultural crops exists because the best available production technologies are not adopted in farmers’ fields. This could be due to farmers’ characteristics (e.g., age, education, lack of knowledge and skills), farm characteristics (e.g., poor soil, difficult terrain, and inaccessibility), and inappropriateness of the technology to farmers’ circumstances (e.g., labor intensive, high investment costs, and poor access to inputs). However, a large portion of this yield gap remains unexplained (Quais, 2015). Small farmers often practice traditional methods of cultivation with their limited knowledge and resources, which does not minimize yield gap. Researchers in various study mentioned the scientific causes of yield gap and its mitigating strategies. However, how many strategies are being practiced by the farmers have rarely been investigated. Under these circumstances stated above, it is important to determine the extent of use of tomato yield gap minimizing strategies by the farmers. Moreover, among the two-vegetable season Robi and Kharip season covers the highest vegetable production area. Therefore, the researcher has undertaken the study titled “Yield Gap Minimizing Strategies towards Tomato Cultivation by the Farmers of Burichang Upazila under Cumilla District”.

In order to make the study manageable the following research questions were taken into consideration:

i. What are the selected characteristics of the farmers that influence their practice of tomato yield gap minimizing strategies?
ii. What is the tomato yields gaps minimizing strategies practiced by the farmers?
iii. What is the extent of practice of tomato yield gap minimizing strategies by the farmers?
iv. What is the contributing relationship between the selected characteristic of the farmers with their tomato yield gap minimizing strategies?

### 1.4 Specific Objective of the Study

1. To describe the socio-economic profile of tomato growers;
2. To determine the extent of tomato yield gap minimizing strategies by the growers;
3. To identify the causes of tomato yield gap; and
4. To explore the contributing relationship between the socio-economic profile of tomato growers with their yield gap minimizing strategies.

### 1.5 Justification of the Study

The size and density of the population in relation to land area and resources development have already caused a high degree of environmental degradation, as reflected by deforestation, loss of wild life, destruction of wet lands and inland fisheries, soil depletion and inland salinity intrusion. Decreasing resources (e.g. land, labour, soil health and water), and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as great challenges to keep pace of food production in the background of increasing population (Brolley, 2015). In every steps of vegetable production system there is huge difference between the research station and the farmers field which is the main reason behind yield gap. To ensure sufficient level of food production for ample population it is important to minimize yield gap of tomato and all other agronomic and horticultural crops.

In this fact stated above, the researcher felt a necessity to identify the extent of tomato yield gap minimizing strategies practiced by the farmers in every steps of vegetable production system. The researcher seems that the findings of the study would be helpful to undertake appropriate policies to mitigate tomato yield gap by the policy makers, researchers and extension providers which will enhance rice production of the country. The knowledge and skills gained by the researcher in conducting this research will enable him to conduct other similar studies in this field.

Considering the above findings, the researcher became interested to undertake a study to "Yield Gap Minimizing Strategies Followed by Tomato Growers of Burichang Upazila under Cumilla District".

**1.6 Assumption of the Study**

The researcher had the following assumptions in mind while undertaking this study:

1. The selected respondents were competent enough to reply the queries made by the researcher.
2. The responses furnished by the respondents were valid and reliable.
3. Information furnished by the respondents included in the sample was the representative opinion of the whole population of the study area.
4. The researcher who acted as interviewer was well adjusted to social and environment condition of the study area. Hence, the data collected by him from the respondents were free from bias.
5. All the data concerning the variables of the study were normally and independently distributed.
6. The findings of the study would give a clear concept on tomato yield gap minimizing strategies practiced by the farmers.

### 1.7 Limitation of the Study

In order to make the study manageable and meaningful from the point of view of research, it was necessary to impose some limitations as stated below:

1. The study was confined to one selected union of Burichang upazila under Cumilla district.
2. The characteristics of farmers in the study area were many and varied but only eleven characteristics were selected for investigation in this study as stated in the objectives.
3. The researcher relied on the data furnished by the tomato farmers from their memory during interview.
4. For some cases, the researcher faced unexpected interference from the over interested side-talkers while collecting data from the target populations. However, the researcher tried to overcome the problem as far as possible with sufficient tact and skill.
5. Reluctance of vegetable farmers to provide information was overcome by establishing proper rapport.

### 1.8 Definition of Related Terms

The terms which have been frequently used throughout the research work are defined and interpreted below:

**Age**

Age of a respondent was defined as the span of his/her life and was operationally measured by the number of years from his/her birth to the time of interview.

**Education**

Education referred to the development of desirable change in knowledge, skill, attitude and ability in an individual through reading, writing, working, observing and other related activities. It was operationalized by the formal education of tomato farmers by taking into account of years he/she spent in formal educational institutions.

**Farm size**

Farm size referred to the cultivated area either owned by the farmer or obtained from others on borga system, the area being estimated in terms of full benefit and half benefit to the farmer respectively. The self-cultivated owned land and cultivated area taken as lease or mortgage from others was recognized as full benefit.

**Annual family income**

The term annual family income referred to the total earning by the earning members from agriculture, livestock, fisheries and other accessible sources (business, service, daily labor etc.) during a year. It was expressed in Thousand Taka.

**Training received**

It was used to refer to the completion of an activity by the farmers which were offered by the government, semi-govt. or non-government organization (s) to improve the knowledge and skills of farmers for better performing an agricultural job. It was measured by the number of days of training received by the respondent.

**Agricultural extension media contact**

Agricultural extension media contact referred to an individual exposure to different information sources and personalities relate to agriculture for dissemination of new technologies.

**Knowledge**

Knowledge referred to the extent of facts or information about an idea, object or persons knows. Regarding knowledge aspects knowledge occurs when an individual is exposed to technologies existence and gain some understanding of how it functions (Rogers, 1995).

**Problem faced**

Problem faced in practicing tomato yield gap minimizing strategies meant any difficult situation which requires some actions to minimize tomato yield gap between "what ought to be" and "what exist". The term problem faced referred to different problem faced by the farmers during practicing tomato yield gap minimizing strategies.

**Profit**

Profit referred to the monetary surplus left to a producer or employer after deducting wages, rent, cost of raw materials, etc.

**Strategy**

According to Oxford Dictionary, "Strategy is a plan of action designed to achieve a long-term or overall aim." According to Business Dictionary, "Strategy is a method or plan of action to bring about a desired future, such as achievement of a goal or solution to a problem."

**Yield Gap**

The difference between the potential farm yield and the actual average farm yield is termed as yield gap (Uddin, 2009).

# CHAPTER II

# REVIEW OF LITERATURE

This is an exclusively a thesis paper. So, specific methods of studies are involved to prepare this thesis paper. This thesis paper mainly depends on the primary and secondary data. Different published reports of different journals mainly supported in providing data for this paper. It has been prepared by comprehensive studies of various articles published in different journals, books and proceedings available in the libraries of Sher-e- Bangla Agricultural University, Bangladesh Agricultural Research Institute, Bangladesh Agricultural Research Council, Hortex Foundation and Department of Agricultural Extension (DAE). Different information's has been collected through contact with respective persons, major professor and Internet facilities to enrich this information.

## 2.1 Concept of Crop Yield Gap

The concept of yield gap originated from the studies conducted by IRRI in 1970's. The difference between the potential farm yield and the actual average farm yield is termed as yield gap. Yield gap has at least two components. (i) Gap I- Environmental difference and non-transferable factors. This is mainly due to the factors those are generally not transferable, such as environmental conditions and some built-in component technologies available at research stations. Therefore, it cannot be narrowed or is not exploitable. (ii) Gap II- Difference in crop management. This is mainly due to differences in management practices. This gap exists as farmers use sub-optimal doses of inputs and cultural practices. Gap II is manageable and can be narrowed by deploying more efforts in research and extension services as well as Governments' appropriate intervention particularly on the institutional issues. Gap II was considered in this study.

## 2.2 Factors Responsible to Yield Gaps in Crop

Yield gaps is actually present, due to the following factors: (i) Physical factors: problem soils, poor water management, drought, flash floods and temperature stresses; (ii) Biophysical factors: varieties, seeds, weeds, insect, diseases and pests, inadequate crop management; (iii) Post-harvest losses, which vary from 10-30% yield gap; (iv) Socio-economic factors: labour shortage, cost-benefit, farmers' knowledge, skills and welfare conditions; (iv) Institutional factors: government policies, rice price, agricultural credit and input supply, land tenure, agricultural research and extension (Ramasamy, 1996).

## 2.3 Estimation of Crop Yield Gap

A study was also undertaken to assess yield gap in tomato (var. Ratan) and radish (var. Tasaki sun). The yield gaps were found to be 36.68% and 40.28%, respectively (Matin et al., 1996; Roy, 1997). It is thus evident that yield gaps in different crops varied from 19% to 64% (Mondal, 2011).

A yield gap study was carried out by OFRD on wheat (var. Kanchan) at the MLT site Palashbari, Rangpur (OFRD, 2003-2004). It was observed that the better managed plot gave higher yield of 2.56 tn/ha whereas the average managed farmers’ plot yield was 1.87 tn/ha indicating a yield gap of 27%. A similar study was undertaken at the MLT site, Atgharia upazila of Pabna district to evaluate the yield gap in mustard using the variety BARI Sharisha-13 (OFRD, 2008-2009). Better managed plots gave higher yield (1366 kg/ha) than farmers’ practice (894 kg/ha) with a yield gap of 35.03%.

Yield gaps of groundnut and sesame were found to be 26.66% and 33.33%, respectively (ORC, BARI, 2002). In Potato and sweet potato, yield gaps were 44.72 and 64.01%, respectively, between demonstration and farmers’ average. (OFRD 2003-2004). Yield gap study was also conducted by OFRD with chickpea (var. BARI Chola-5). The study revealed yield gap of 31.43% in chickpea (OFRD 2003-2004).

To evaluate the yield gap in boro rice, a study was conducted by BRRI in Rajapur village of Bhanga upazila of Faridpur and Meghdubi village of Gazipur district. Under farmers’ practice, the yield of boro rice were 4.47 tn/ha and 3.67 tn/ha, while the potential yields with better management were 5.90 tn/ha and 4.73 tn/ha at Rajapur and Meghdubi villages, respectively. The yield gaps were thus 1.43 tn/ha and 1.06 tn/ha which were 24.24% and 22.41% of the potential yield at Rajapur and Meghdubi, respectively (Alam, 2006).

Roy (1997) reported that yield gaps were found to 44.44% and 60.00% in aus and aman, respectively. The average productivity (7 $Mg·ha^{-1}$) of this system is far below attainable yields (14 $Mg·ha^{-1}$) in farmers' fields, resulting in a large yield gap mainly due to farmers' traditional management practices. Yield gap in rice was about 1.74 tn/ha and at least Tk. 1260 billion could be earned from the additional production annually by narrowing the yield gap (BRRI, 2010).

## 2.4 Yield gap of tomato cultivation

Berrueta et al., (2020) yield gap analysis is a powerful method to explore gap's breadth between potential yields, attainable and those realized in farmers' fields, identifying constraints to production and assess opportunities to yield increase. We assessed yields and yield components across two seasons, in 110 greenhouse tomato (*Solanum lycopersicum*) crops during 2014/15 and 2015/16 in the south region of Uruguay, and compared them with potential and attainable yield. Potential yield was calculated with a simulation model based on photosynthetic active radiation (PAR) and light use efficiency, and TOMSIM to estimate assimilate partition and fruit yield. Since yield was primarily determined by cumulative PAR intercepted, a boundary function was fitted to estimate attainable yield as a function of cumulative PAR intercepted. Our study quantified a yield gap of 10.7 kg m−2 or 44 % relative to potential. Overall gap was divided into three components: difference between actual and attainable (45 % of total gap), attainable and potential with actual greenhouse PAR transmissivity (29 % of total gap) and between potential with actual transmissivity and potential with 70 % of greenhouse transmissivity (26 % of total gap). For long summer and short spring/summer crops the greatest impact in yield could be obtained by increasing leaf area index by reducing plant lowering operations and leaf pruning intensity, and by increasing plant density. For autumn crops, yield could be improved by earlier planting, reducing leaf pruning intensity after harvest beginning, and increasing greenhouse transmissivity by more frequent plastic cover renewal and removing roofs' shading screens and whitening.

Lammers, (2015) tomatoes for fresh consumption are economically the most important horticultural crop in Uruguay. The average yield of greenhouse tomatoes between 2002 and 2010 fluctuated around 9.3 kg m-2 in the South of Uruguay, with a high variation in yields between producers. The actual yield gap of greenhouse tomatoes in the South of Uruguay is estimated at 54%. Knowing which factors explain these yield-gaps is the first step to design strategies to reduce the yield-gaps between producers. The purpose of this thesis is to contribute to the reduction of the yield-gaps in greenhouse tomatoes in the South of Uruguay, by quantifying them and identifying their main causes. From July 2014 until May 2015, 22 crops were evaluated in a representative sample of 18 producers. The methodology used is based on the Regional Agronomic Diagnosis and Yield-gap analysis. Variables were analysed related to the potential yield, limited yield and reduced yield. Data was analysed using cluster analysis, path analysis, Spearman correlations and CART analysis. The average yield of the crops was 9.4 ± 4.6 kg m-2 in the year 2015, with big differences between yields, ranging from 0.0 to 20.1 kg m2. The yield gap was approximately 48%. The yield component that explained more the differences in yield was the length of the growing cycle. The major cause of the variability in yield was the total amount of potassium added by fertigation throughout the growing cycle. Crops with high input of potassium (>20.9 g m-2, N=10) had an average yield of 13.4 ± 3.0 kg.m-2. Crops with low input of potassium (4.75 hours, N=6) had a yield of 5.4 ± 0.6 kg m-2. In order to contribute to the reduction of yield-gaps, adaptations in management could be made without the increase of production costs. This adaptation would include better crop planning and better fertilizer management regarding amounts and moments of application. A first step for better humidity control could be placing humidity and temperature sensors inside the greenhouses.

Singh et al., (2018) the study was conducted on impact of frontline demonstrations in adoption of production technology and economics of tomato at farmer's field of three adopted villages Seoni district, Madhya Pradesh. Prevailing farmer's practices were treated as control for comparison with demonstrated technology. The main objective of front line demonstrations (FLDs) was to demonstrate newly released crop production and protection technologies and its management practices at the farmer's field under different agro-climatic regions and farming situations. The result of FLDs conducted by Krishi Vigyan Kendra, Seoni in tomato crop showed a greater impact on farmer's livelihood due to significant increase in yield over local check. The extension gap ranged between 99.47 to 141.24 q/ha, whereas the trend of technology gap ranged between 313.90 to 353.53 q/ ha. The benefit cost ratio (B:C) was recorded higher i.e. 3.44 to 4.00 under demonstrated practice, while it was 3.02 to 3.54 under check practice. The results of improved technological intervention brought out 33.49 to 50.70 per cent increased in yield of tomato. The overall adoption level of demonstrated tomato production technology was increased about 231.35 per cent due to FLDs, if appropriate package and practices are followed.

Singh et al., (2018) tomato (*Solanum lycopersicum* L) is one of the major vegetable crops cultivated in India, which plays a major role in supplementing the income of small and marginal farmers of Seoni district of Madhya Pradesh. The front line demonstrations (FLDs) were conducted on farmer’s field in Seoni district of Madhya Pradesh for three consecutive years (2014-15 to 2016-17) at two adopted villages. Prevailing farmer's practices were treated as control for comparison with demonstrated technology. The result of FLDs conducted by Krishi Vigyan Kendra, Seoni in tomato crop shows a greater impact on farmer’s livelihood due to significant increase in yield over local check. The extension gap ranged between 78.78 and 136.08 q/ha, whereas the trend of technology gap ranged between 394.58 and 424.71 q/ ha. The benefit cost ratio (B: C) was recorded higher i.e. 2.44 to 2.90 under demonstrated practice, while it was 1.82 to 2.40 under check practice. The results of improved technological intervention brought out 28.47 to 71.92 % increase in yield of tomato. The overall adoption level of demonstrated tomato production technology was increased about 283% due to FLDs, if appropriate package and practices are followed.

### 2.5 Constrains to Minimize Yield Gap in Bangladesh

The productivity and sustainability of rice-based cropping systems are threatened because of the following factors: (i) inefficient use of fertilizer, water, and labor; (ii) increasing scarcity of water and labor; (iii) climate change; (iv) emerging energy crisis and rising fuel prices; (v) emerging socio-economic changes such as urbanization, migration of labor, and preference for nonagricultural work (Ladha et al., 2009). Major challenges to implement the interventions include shrinking net cropped area, scarcity of water for irrigation and increasing pressure on soil fertility. In addition, recent increases in the prices of farm inputs in relation to outputs, fewer off-farm work opportunities for supplementing farm income, reduced remittances from relatives working outside villages, and declining income and purchasing power of poor consumers have threatened the existence of rice producers and consumers (Ladha et al., 2009). Moreover, imbalanced fertilization and increased cropping intensity is hampering soil health. Due to deterioration of soil and use of excessive agrochemicals soil organic matter content become decreasing day by day. Declining ground water table is a common scenario across Bangladesh which greatly affect Boro rice (Kabir, et al., 2105).

## 2.6 Strategies Provided to Minimize Yield Gap

The yield gaps are mainly caused by biological, socio-economic, climatic, institutional and policy related factors. Different strategies, such as integrated crop management (ICM) practices, timely supply of inputs including credit to farmers, research and extension collaboration to transfer the new technologies can minimize crop yield gap (Mondal, 2011).

Three major interventions i.e (i) accelerating genetic gain; (ii) minimizing yield gap and (iii) curtailing adoption lag are proposed to break the barriers to achieve the target. Smart technology such as, location specific variety, profitable cropping sequences, innovative cultural management, and mechanization coupled with smart dissemination using multiple means, would ease production barriers (Kabir et al., 2015).

IRRI (2015) provided 13 steps to successful rice production. These are: (i) use of crop calendar; (ii) choose the best variety; (iii) use high quality seed; (iv) prepare and level the fields well; (v) plant on time; (vi) weed early; (vii) fertilize to maximize returns; (viii) use water efficiently; (ix) control pests and diseases effectively; (x) harvest on time; (xi) store safely; (xii) mill efficiently; (xiii) understand the market.

BRRI (2016), provided 20 steps to obtain desire rice yield. These are: (i)selection of right variety, (ii) use of quality seed, (iii) seed selection, (iv) seed purification, (v) seed soaking, (vi) making of seedbed, (vii) seed rate, (viii) rearing of seedbed, (ix) age of seedling, (x) picking up of seedlings, (xi) carrying of seedlings, (xii) land preparation, (xiii) sowing of seedlings, (xiv) time of sowing seedlings, (xv) fertilizer management, (xvi) removal of weeds, (xvii) irrigation management, (xviii) pests management, (xix) disease management, (xx) harvesting, threshing and storing.

To summarize yield gap minimizing strategies, the researcher had considered following two techniques; (i) It has developed based on reference booklet of BRRI dhan29 Production Manual (BRRI, 2016); (ii) By taking expert opinion from subject matter specialists; validity test of the above mentioned recommended steps in the sturdy area according to persuasion, knowledge and capacity of the farmers. The strategies are discussed below.

### 2.6.1 Use of crop calendar

A crop calendar is a picture of rice growing season which includes: crop production from the fallow; land preparation; crop establishment and maintenance through harvest and storage. By using a crop calendar, farm activities are better planned, and performed at the right time. It is easier to organize labor and obtain inputs such as seed and fertilizer. Better planning will decrease input costs and increase yields. A crop calendar can be created by determining the best date to plant and determining the time the variety takes from planting to harvest (short duration, 100–120 days; medium duration, 120– 140 days; long duration, 160 days or more). The date of planting and when each other operation needs to be done (plowing, weeding, fertilizing, and harvesting) should be marked on the calendar (IRRI, 2015).

However, extent of practice of crop calendar by the farmers as a strategy to minimize yield gap in Bangladesh has not been measured so far, which requires further research.

### 2.6.2 Choose the best variety

Varieties should be selected based on good yield potential, resistance to disease, good eating qualities, high milling yield, and are suitable for the market. During selecting variety characteristics like crop duration, crop height, grain quality etc. should be checked (IRRI, 2015).

Since 2017, BRRI has developed 86 rice varieties, and BINA has developed 16 rice varieties for different environment and seasons. In Boro season, BR 58 is 7-10 days earlier than widely adopted BRRI dhan29 with similar yield potential and grain quality. Whereas BRRI dhan60 has ~1.0 t $ha^{-1}$ yield advantage with extra-long slender grain and 3-4 days longer growth duration than another mega-variety BRRI dhan28. BRRI dhan50 and BRRI dhan63 are the export potential premium quality high yielding (6.0-7.0 t $ha^{-1}$). BRRI dhan74 is a zinc enriched (24.2 ppm) variety, yielding ability of 7.1–8.3 t $ha^{-1}$, 147 days duration, 28% amylose content, moderately tolerant to blast disease. BRRI dhan67 has slender grains is better tolerant to salinity compared to BRRI dhan47 (Kabir et al., 2015). The average yield of BRRI dhan29 was 6.1 t/h. It is highest among the inbred improved varieties. BR 28 however produced almost 1.0 t/ ha lower yield than BRRI dhan29. It is also lower yielding compared to some earlier popular varieties such as IR8 (5.99 tn/ha), BRRI dhan3 (5.62 tn/ha), BRRI dhan8 (5.71 tn/ha) and BINA 6 (5.38 tn/ha). The popularity of BR 28 is due to its shorter life cycle. It matures 2-3 weeks earlier than BRRI dhan29 if planted on the same date with seedlings of same age. BRRI dhan29 is grown in low-lying land. BRRI dhan28 is grown in medium and higher lands. (Hossain et al., 2006).

The average yield of BRI dhan 29 is 6.13 tn/ha and 5.11 tn/ha for BRRI dhan28, compared to 3.92 tn/ha for BRRI dhan11 and 3.79 for Swarna. The hybrid rice varieties that have 20% yield advantage than the inbred high yielding varieties are also grown during the boro season (Hossain et al 2002). The popular Indian varieties found in Boro season are Ratna, Bhajan, Minikit, Parijat, Nayanmoni and Jaya. These varieties had appeal to the farmers because of their shorter maturity (Parijat), drought tolerance (Nayon Moni), superior grain quality (Minikit). The highest yielding among these varieties was Bhajan with a yield of 5.99 tn/ha, almost similar to BRRI dhan29 (Hossain et al., 2006).

However, farmers' choice of best varieties and practice of using best varieties as a strategy to minimize yield gap has not measured yet, which requires further research.

### 2.6.3 Use of best quality seeds

Ensuring quality seed supply has considerable effect in rice yield gap minimization. BRRI annually produces around 100 tons "Breeder Seed", from which 6.5 lakh ton "Certified Seed" can be produced. However, 35% of the quality seed is now being supplied by the government. The rest of the seed sources are the farmers' saved rice seed produced for their own food, NGO's seed, private traders or local market. Those are not good quality seeds as a whole (Kabir et al., 2015). More than 50% of the farmers in Bangladesh use seeds from their own harvest. BADC is the main government organization in charge of producing and marketing quality seeds, contributes about 25% of the seeds planted (Hossain et al., 2012).

Demonstration plot (DP) gave 25.15% higher yield than non-demonstration plot (NDP) due to use of best quality seed, appropriate age of seedlings (30 days), closer spacing, optimum number of seedlings per hill, use of balanced fertilizer and pest control in proper time. Although cultivation cost of DP was higher (Tk.2218 $ha^{-1}$) than that of NDP (Razzaque et al., 2007).

Plot planted with IRRl supplied seeds had 7% higher yield than the plot planted with farmers-kept seeds in the site where the yield level is already high (De Datta, 1981). The deterioration of the seed vigor in rice crop accounted for 20% of the yield losses (Shenoy et al., 1988). Most of the traditional varieties have been degenerated with mixture of other varieties and weeds, which is another reason for low yield besides genetic traits (Hossain et al., 2006).

Healthy seeds should be selected by grading. Seeds should be dipped in water solution (40 litre + 2kg Urea). Seed should be treated with Agrosan GN 1.5 g/kg seed or Granosan M 1g/kg seed (Islam et., al 2007, BRRI, 2016). Sprouted seeds are sown in the nursery bed for rising seedling. When the age of seedlings become 40-45 days (boro rice), 20-35 days (aman rice) and 20-30 days (aus rice) then they are transplanted in the main field. (Islam et. al., 2007. BRRI, 2016).

However, extent of practice of using quality seed (truthfully leveled seed, registered seed, certified seed, foundation seed) and seed treatment as strategy to minimize yield gap by the farmers has not been measured so far, which requires further research.

### 2.6.4 Land preparation for vegetable production

Land preparation in vegetable fields is normally carried out after bunding and flooding. This ensures that the fields are wet enough to allow ploughing and strong enough to give reasonable levels of traction or grip to the tractor. Manual land preparation is predominately practiced among small holder farmers. The second operation is carried out in the vegetable to reduce clog sizes, weed control, and incorporate fertilizers in the soil and puddling. Land preparation ends up with final operation that adequately levels the field. Land Preparation and leveling improves and restore soil fertility, ensures proper aeration and good root penetration, proper land levelling, improves soil workability, improves nutrient uptake by crops (KRKB, 2017).

Proper levelling in the field solves more than 50% of the problems in vegetable production. To ensure a well-leveled land, it is recommended to have 3-5 cm soil in the field using a metal or wooden plank (Bautista, 2016).

However, farmers' knowledge on land preparation and practice of land preparation as a strategy to minimize yield gap have not been measured so far, which requires further research.

### 2.6.5 Use of recommended doses of fertilizer

Use of balanced fertilizers is a necessary mean to explore yield potential of varieties. Farmers apply fertilizers, pesticide, herbicide and weedicide according to their own experience (Sayed et al., 2015).

Fertilizer dose recommended for BR 29: Urea 30-40 kg/bigha, TSP 7-14 kg/bigha, MoP 8-16 kg/bigha, Gypsum 4-8 kg/bigha and $ZnSO_4$ 0.7-1.4 kg/bigha. Fertilizer dose recommended for BR 28: Urea 30-40 kg/bigha, TSP 7-10 kg/bigha, MoP 8-16 kg/bigha, Gypsum 4-11 kg/bigha and ZnSO4 0.7-1.0 kg/bigha (BR 29 production manual). Application of fertilizer should be done according to soil type and expected yield. Organic fertilizer (manure, compost, straw, husk, plant leaves) should be used whenever possible, especially in nurseries. TSP, MoP, Gypsum and ZnSO4 all these fertilizers should be applied during final land preparation. Urea should be applied in 3 equal splits. The first 1/3$^{rd}$ should be applied at 20 DAT as top dressing, the 2$^{nd}$ 1/3$^{rd}$ should be applied during early tillering stage (30-35 DAT) and last 1/3$^{rd}$ at panicle initiation stage (50-55) DAT as top dressing (BRRI, 2016). Instead of the using normal urea, the urea super granule is an effective to reduce fertilizer use for optimum yield (Paul et al., 2013; Qurashi et al., 2013).

Fertilizer used per hectare was found to vary according to vegetable cultivations. Compared to high yielding or hybrid varieties, use of all types of fertilizers was considerably low for traditional varieties. Per hectare use of Urea, TSP and MoP for traditional varieties of vegetable were found to be 96.4 kg, 34.4 kg and 16.4 Kg. while for the most popular HYV vegetables, BR 29, these were 204.2 kg, 95.7 kg and 56.0 kg respectively. Again, uses of fertilizers for Hybrid vegetable like Jagoran, Hira, etc. were found to be a bit higher than HYVs. Use of fertilizers was also found to vary considerably in different districts. For example, in the case of Urea, high dose is used in the districts of Chuadanga (260 kg/ha), Munshigan (236 kg / ha), Sirajganj (213 kg / ha), etc. compared to the districts of Patuakhali (73 kg/ha), Maulvibazar (86 kg/ha), Pirojpur (95 kg/ha), etc. (Hossain et al., 2006).

However, extent of practice of recommended doses of fertilizers in crops by the farmers as a strategy to minimize yield gap has not been measured so far, which requires further research.

### 2.6.6 Timely transplanting of seedlings and spacing

Effect of planting date on plant height, total sterile spikelet per panicle, 1000 grains weight, total tiller number, panicle number per $m^2$, grain yield and harvest index was significant at 0.01 probability level. Also planting date had a significant effect on fertile tiller number at 0.05 probability levels. Seedling had a significant effect on fertile tiller at 0.05 probability level. When date of planting is delayed grain yield decreases because the 1000 grains weight decreases and total strile spikelet per panicle increases (Faghani, et. al., 2011).

Delayed transplanting of aman decreases spikelet fertility and reduces yield due to cold stress at the flowering stage (Nahar et al., 2009b). In the case of boro, optimum sowing time for Boro rice is mid-December to mid-January, early-planted crops face low-temperature stress at vegetative as well as reproductive stages and late-planted ones face high-temperature stress at the reproductive stage (Haque, 2006).

The age of seedling varies from variety to variety. For short duration varieties 3-4 week and for long duration varieties 5-6 weeks old seedlings are the optimum age for planting. In boro season, 35-45 days old seedlings should be transplanted. In saline soil of southern region, nursery seed bed should be made before optimum time of seed sowing to avoid damage due to salinity in panicle initiation stage during (March-April). Spacing should be made line to line 25-20 cm, plant to plant 15-20 cm and 2-3 seedlings per hill (BRRI, 2016).

However, farmers' knowledge on timely transplanting of seedlings as a strategy to minimize yield gap has not been measured so far, which requires further research.

### 2.6.7 Weed management

About 72.5% and 15% farmers controlled their weed by hand weeding method and weedicide application respectively (Sayed et al. 2015). Knowing the critical period for weed control (CPWC) is useful in making decisions on the need for and timing of weed control and in achieving efficient herbicide use from both biological and economic perspectives (Knezevic et al., 2002).

Weed problems are the result of permanent monocropping in rice. Rainfed rice is normally affected by species such as *Rottboellia cochinchinensis*, *Cynodon dactylon* and

*Cyperus rotundus*, while other species prevail in flooding conditions. *Echinochloa*, *E. colona*, *Cynodon dactylon*, *Cyperus rotundus* are major weeds in Bangladesh (Labrada, 1996). Alchlor, Butachlor, Nutrofen and Oxidiazon are the most commonly used pre-emergence herbicide in Bangladesh. 2,4-Disopropyl Ester is the most commonly used post-emergence (30-40 DAT) herbicide in Bangladesh. Mulching reduces weed growth although substantially greater soil cover is required to suppress weeds (Naudin et al., 2011).

For Boro rice, land should be kept free from weeds up to 40-50 days after transplanting. Generally, 2 times weeding is done. 1$^{st}$ weeding is done 15 DAT and 2$^{nd}$ weeding is done 30-35 DAT. In case of dense weed population, 3$^{rd}$ weeding should be done 45-50 DAT. It is important to use Japanies Rice Weeder in 1$^{st}$ weeding when stagnant water is available and during 2$^{nd}$ weed operation manual weeding is effective (Uddin, et. al., 2009).

However, farmers' knowledge and extent of practice of recommended weeding as a strategy to minimize yield gap has not been measured so far, which requires further research.

### 2.6.8 Irrigation management

In an efficient system, each 1 kg of grain production requires a minimum of 2,000 liters of water (IRRI, 2015). Farmer's paid on an average 4800 Tk. per hectare for irrigation purpose (Sayed et al., 2015). A large gap exists between actual water needed for growing rice and that used by farmers (Bhuiyan et al., 1999). In 2008, the national irrigation coverage was 5.05 million ha, about 60% of total cultivable land, with groundwater covering 79% and surface water 21% (FAO, 2010). The precondition for growing high yielding varieties in boro season is proper water management. In favorable ecological areas, about 92% of the farmers use irrigation; of these, only 28% have own irrigation equipment, while 62% buy irrigation water (Hossain et al., 2013).

Instead of flood irrigation, alternate wet and dry (AWD) methods of irrigation can be used. Intermittent irrigation of 3 days and 7 days intervals produced water savings of 55% and 74% compared to continuous flooding. Plant height and leaf area were greater in plants exposed to intermittent irrigation of 3 days intervals (Pascula et al., 2016).

However, extent of practice of recommended irrigation by the farmers as a strategy to minimize rice yield gap by the farmers has not been measured so far, which requires further research.

### 2.6.9 Disease management

Rice diseases always have a significant impact on rice productivity. In Bangladesh, a total of 32 rice diseases have been identified. Bacterial leaf blight, sheath blight, leaf blast, sheath blast, tungro, stem rot, brown spot, bakani are the major rice diseases in Bangladesh (Shelly, et al., 2016). Bacterial leaf blight and neck blast are chronic diseases both in T. Aman and Boro season in Bangladesh while severity of sheath blight has been higher in T. Aman season. Bacterial leaf streak has become an emerging disease in both
T. Aman and Boro season. Tungro and Root knot diseases are serious threat to Aus rice cultivation in Bangladesh. BR 28 is being affected seriously with leaf or neck blast although it had been considered as moderately resistant to blast since its release (BRRI, 2015a). In case of fungal diseases i.e Brown spot, Blast, Stem root, Seed rot and Bakani seed treatment with Bevistin or Vitavax @ 0.4% of seed weight is recommended. In case of Bacterial disease i.e Bacterial leaf blight and Bacterial leaf streak seed treatment with Tilth 250 EC @ 1g/L of water or Homai @ 2.5-3g/kg is recommended. In case of viral disease i.e Tungro, Mosaic, Dwarf Diazinon @ 15 ml/10 L of water spray is recommended (BRRI, 2015b). Late planting is also vulnerable to production of sclerotia (the resting stage of the pathogen), the inoculum source for next year's disease infection (Kabir et al., 2015).

However, extent of practice of recommended seed treatment and use of recommended fungicides by the farmers to avoid seed born diseases of rice has not measured yet, which requires further research.

### 2.6.10 Integrated pest management

Brown plant hopper, rice stem borer, green leaf hopper, white-backed plant hopper, rice gall midge, rice hispa and rice leaf folder are common insect pests of rice in Bangladesh (Alam, 2013, Nasiruddin and Roy, 2012, Fatema et al., 1999; Kamal et al., 1993; Alam, 2006; BRRI, 2000, 2001, 2007, 2009). Weeds and pests are important biotic constraints reducing rice yield nearly 25%. Crop rotations sometimes allow the inclusion of nitrogen fixing legumes and break pest and disease cycles of crops that are too frequently planted in the same field (Chikowo et al., 2004). The overuse of fertilizers led to high pest and disease infestations and resulted in even higher usage of pesticides (Hossain et al., 2006). A strong understanding of the population ecology of insect, rodent, and weed pests, and the behavior of rodents and insects is important to effectively manage them (Azucena et al., 2015). The traditional method leads to harvesting a little earlier makes the fields latter vulnerable to pests (Rahman, 2016). Dikes must be cleaned to remove grasses or weeds that harbor pests. Too much vegetative growth makes the crop more susceptible to late-season diseases and instability, which causes the plants to fall over called lodging (Chauhan et al., 2006).

Integrated pest management (IPM) plays significant role in reducing pest infestation in Bangladesh. Crop based pest model is invented. Invading new pests like Rice black beetle could evolve causing threat. Furthermore, some insects might change their biotype (e.g., BPH). Therefore, preventive measures by strengthening surveillance and field monitoring system for pests (such as, using Light Trap and Yellow Sticky Trap) and environment friendly pest management options like perching, eco-engineering with pest and natural enemies, and establishment of Owl watching tower for rat control should be taken into account (Kabir et al., 2015).

Ghimire and Kafle (2014) conducted a study on IPM and its Adoption by the farmers in Nepal. The study revealed that about 53 percent of farmers were satisfied with the practice.

However, extent of practice of IPM as a strategy to minimize rice yield gap has not measured yet, which requires further research.

## 2.7 Review of Concerning Relationships of the Selected Characteristics of the Farmers with their Yield Gap Minimizing Strategies Practiced

Tomato yield gap minimizing strategy is a relatively new research concept. Therefore, no direct study regarding relationship between the selected characteristics of the farmers and their tomato yield gap minimizing strategies were found.

Faruq (2017) found that farmers age had significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers. Hasan (2015) found that farmers age had significant and positive contribution to adoption of modern practices in rice cultivation. Talukder (2006) found that farmers age had significant and positive relationship with their adoption to selected rice production practices. Ahmed (2006) found that age had non-significant relationship with adoption to selected rice production technologies by the farmers.Faruq (2017) found that farmers education had significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers.

Taluker (2006) found non-significant relationship between education and adoption of rice production practices of the farmers. Hasan (2015) found significant contribution of farmers education to adoption of modern practices in rice cultivation. Ahmed (2006) found positive significant relationship between farmers’ education and adoption of selected rice production technologies. Faruq (2017) found that farmers age had no significant and negative contribution to boro rice yield gap minimizing strategies practiced by the farmers. Talukder (2006) found positive significant relationship between farm size and adoption of selected rice production practices.

On the other hand, Hasan (2015) found non- significant contribution of farm size to adoption of modern practices in rice cultivation. Ahmed (2006) also found non-significant relationship between farm size and adoption of selected rice production technologies. Faruq (2017) found that farmers annual family income had no significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers. Talukder (2006) and Ahmed (2006) found positive significant relationship between annual family income and farmers adoption of selected rice production practices and technologies.

On the other hand, Hasan (2015) found no significant contribution of annual family income to adoption of modern practices in rice cultivation by the farmers. Ahmed et al., (2009), found that cultivation of potato was more profitable than boro rice in view point of farmers.

Haque (2006), found rice seed production was not as profitable as investment in rice seed cultivation. Faruq (2017) found that farmers yield gap had significant and negative contribution to boro rice yield gap minimizing strategies practiced by the farmers. Faruq (2017) found that farmers training had significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers.

Ahmed (2006) found no significant relationship between training exposure and adoption of selected rice production technologies by the garo farmers. Hasan (2015) also found no significant contribution of training exposure to adoption of modern practices in rice cultivation by the farmers. Faruq (2017) found that farmers extension media contact had significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers. Talukder (2006) and Ahmed (2006) found significant positive relationship between extension contact and adoption of selected rice production practices and technologies by the farmers.

Hasan (2015) also found significant contribution of extension contact to adoption of modern practices in rice cultivation by the farmers. Faruq (2017) found that farmers knowledge had on significant and positive contribution to boro rice yield gap minimizing strategies practiced by the farmers. Hasan (2015) found no significant contribution of rice production knowledge to adoption of modern practices in rice cultivation by the farmers. On the other hand, Talukder (2006) and Ahmed (2006) found significant positive relationship between knowledge and adoption of selected rice production practices and technologies. Faruq (2017) found that farmers problem had significant and negative contribution to boro rice yield gap minimizing strategies practiced by the farmers. Talukder (2006) found significant positive relationship between problems and adoption of selected rice production practices by the farmers.

## 2.8 Research Gap

According to the review of literature of the present study the researcher has found the following research gaps:

- Very few researches on yield gap minimizing strategies of tomato cultivation by the farmers have so far been conducted and no research has so far been conducted to measure the tomato yield gap minimizing strategies practiced by the farmers. Hence the researcher carried out the present study to determine the tomato yield gap minimizing strategies practiced by the farmers.
- Limited research work has so far been conducted to measure farmers level of problem faced in practicing tomato yield gap minimizing strategies and extent of practices of selected strategies i.e. use of crop calendar, quality seed, seed treatment with recommended doses of fungicides, sowing seedling in optimum time, use of recommended weeding, recommended irrigation, recommended doses of fertilizer, use of IPM, harvesting during maturity index and following recommended steps of post-harvest operation by the farmers to minimize tomato yield gap. The researcher carried out the study to explore the extent of practices of those strategies and level of problem faced by the famers in practicing those strategies to minimize tomato yield gap.
- Limited research work has so far been carried out to explore the contributing relationship between each of the selected characteristics of the farmers with their yield gap minimizing strategies of tomato cultivation. The researcher carried out the study to explore the contributing relationship between each of the selected characteristics of the farmers with their yield gap minimizing strategies of tomato cultivation.

## 2.9 Conceptual Framework of the Study

The present study would be tried to focus two concepts, first, the farmers’ selected characteristics and the second, their gap minimizing strategies of tomato cultivars. Gap minimizing strategies of tomato cultivars may be influenced and affected through interacting forces in his surroundings. Yield gap minimizing strategies of tomato cultivars may also be influenced by various characteristics. In this study, farmers' characteristics have only been taken into consideration. Moreover, it is deal with all the characteristics in a single study. It is therefore, necessary to limit the characteristics which include: age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato cultivation and causes of yield gap in tomato cultivation. These characteristics are the independent variables of this study, while yield gap minimizing strategies of tomato cultivation being the main focus of the study constituted the only dependent variable. A simple conceptual framework in this connection has been presented in Figure 2.1.

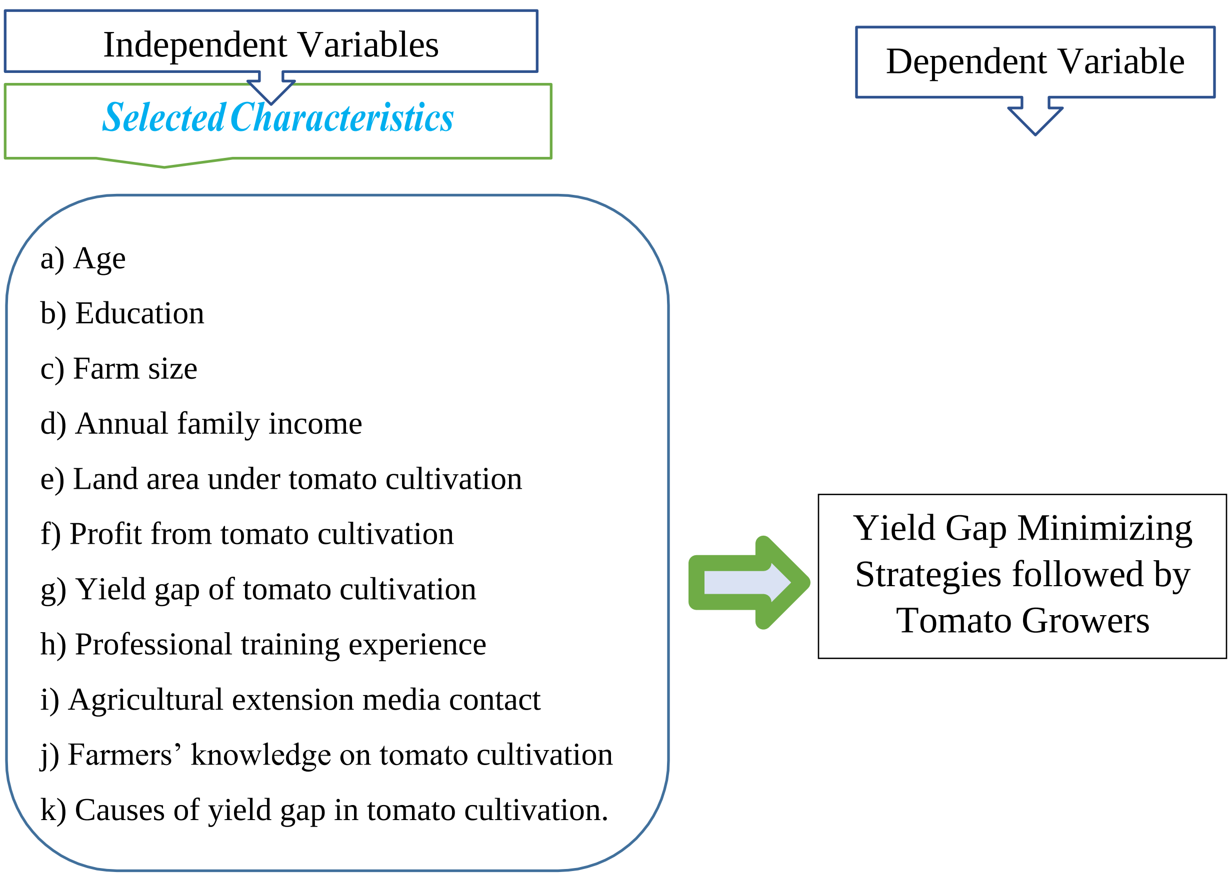


**Figure 2.1: Conceptual framework of the study**

# CHAPTER III
# METHODOLOGY

Methods play crucial role in a systematic analysis. To fulfill the goals of the find out about, a researcher must be very careful while formulating strategies and procedures in engaging in the research. According to Mingers (2001), analysis method is a structured set of pointers or activities to generate legitimate and dependable research results. This chapter of the thesis illustrates the research methods and procedures used to collect and analyze the data for answering the research questions and reaching the purposes. The methods and operational procedures followed in engaging in the learn about e.g. selection of learn about space, sampling procedures, instrumentation, categorization of variables, choice of knowledge, measurement of the variables and statistical measurements. A chronological description of the methodology adopted in conducting this analysis work has been offered in this bankruptcy.

## 3.1 Locale of the Study

The study was conducted in Burichang Upazila under Cumilla District. Burichang Upazila (Cumilla district) area 163.76 sq km, located in between 23°28' and 23°37 north latitude and in between 91°02' and 91°13' east longitudes. It is bounded by Brahmanpara upazila on the north, Cumilla adarsha sadar upazila on the south, Tripura state of India and Cumilla adarsha sadar upazila on the east, Debidwar and Chandina upazilas on the west. The map of Cumilla district has been presented in Figure 3.1 and the specific study locations of Mokam union in Burichang upazila under Cumilla district have also been shown in Figure 3.2.

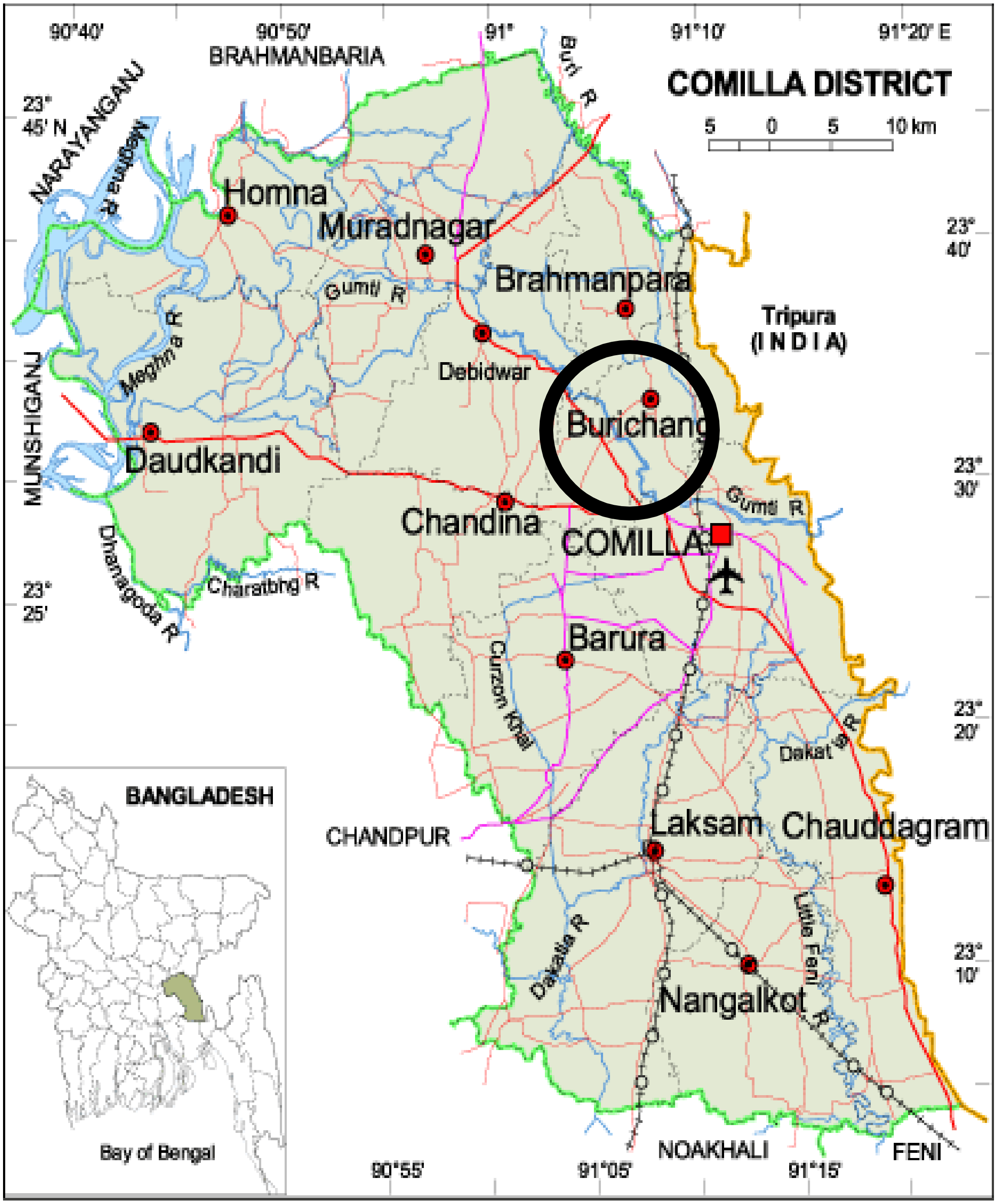


**Figure 3.1: A map of Cumilla district showing Burichang upazila**

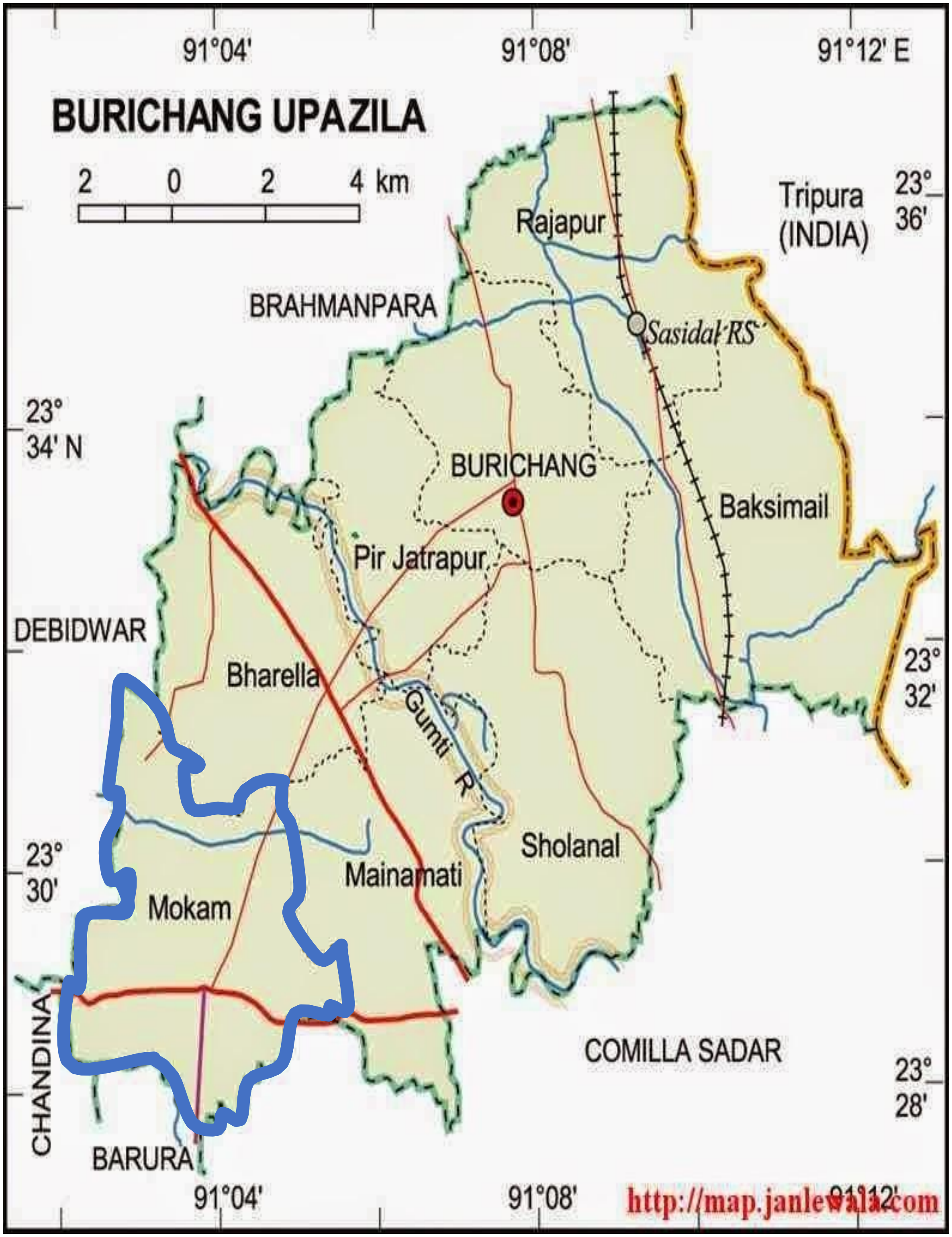


**Figure 3.2: A map of Burichang upazila showing the study area**

### 3.2 Population and Sample of the Study

The head of the farm families of tomato cultivators of Mokam union of Burichang Upazila under Cumilla District were the population of the study. However, representative sample from the population were taken for collection of data following random sampling technique. One farmer (who mainly operated the tomato cultivation) from each of the farm families was considered as the respondent. Updated lists of all tomato farmers of the selected villages were prepared with the help of SAAOs and local leaders. A purposive random sampling technique was followed to select one district from the whole of Bangladesh, and the same method was used to select the area of the district as well as the villages as the study group. The total number of tomato cultivars of the selected villages was 504; where 155 farm Nimsar village, 168 farm family heads from Nayakamta and 181 farm family heads from Abidpur of Mokam union which constituted the population of the study. The number of tomato cultivars of the selected three villages was 504 which constituted the population of the study. Out of 504 tomato farmers 20 percent of the total population was selected proportionally from the selected villages as the sample by random sampling method. Thus, the total sample size stood at 101, so, 101 tomato cultivars were taken as the sample of the study. Moreover, a reserved list of 10 tomato cultivars was prepared for use when the tomato cultivars under sample were not available during data collection. The distribution of the tomato cultivars included in the population, sample and those in the reserve list appears in Table 3.1.

**Table 3.1 Distribution of the tomato growers according to population and reserve list**

| Selected upazila | Selected union | Selected villages | Population | Sample size | Reserve list |
|---|---|---|---|---|---|
| Burichang upazila | Mokam | Nimsar | 155 | 31 | 3 |
| | | Nayakamta | 168 | 34 | 3 |
| | | Abidpur | 181 | 36 | 4 |
| Total | | | 504 | 101 | 10 |

### 3.3 Data Collection Tools

Structured interview schedules were prepared to reach the objectives of the study. The schedule was prepared containing open and closed form of questions. The open questions allowed for the respondents to give answers using their own language and categories (Casley and Kumar, 1998). The questions in this schedule were formulated in a simple and unambiguous way and arranged in a logical order to make it more attractive and comprehensive. The instruments were first developed in English and then translated into Bengali. The survey tools were initially constructed based on an extensive literature reviews and pre-tested. The schedule was pre-tested with 15 randomly selected tomato cultivators in the study area. The pre-test was helpful in identifying faulty questions and statements in the draft schedule. Thus, necessary additions, deletions, modifications and adjustments were made in the schedule on the basis of experiences gained from pre-test. The questionnaires were also checked for validity by supervisor and educational experts at Sher-e-Bangla Agricultural University (SAU). Finally, based on background information, an expert appraisal and the pre-test, the interview schedule was finalized. Data was gathered by the researcher personally. During data collection, necessary cooperation was obtained from field staff of different government and non-government organizations and local leader. The primary data were collected from 12 January to 17 January, 2021. Books, journals, reports and internet documents were used as secondary sources of data supporting or supplementing the empirical findings of the study. The final data collection was started from 22 January and completed in 21 February, 2021.

### 3.4 Variables and their Measurement Techniques

The variable is a characteristic, which can assume varying, or different values in successive individual cases. A research work usually contains at least two important variables viz. independent and dependent variables. An independent variable is that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon. A dependent variable is that factor which appears, disappears or varies as the researcher introduces, removes or varies the independent variable (Townsend, 1953).

At last, he had selected 11 independent variables and one dependent variable. The independent variables were: age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation. The dependent variable of this study was the 'Yield Gap Minimizing Strategies Followed by Tomato Growers of Burichang Upazila under Cumilla District'. The methods and procedures in measuring the variables of this study are presented below:

### 3.5 Measurement of Independent Variables

The 11 characteristics of the commercial vegetable farmers mentioned above constitute the independent variables of this study. The following procedures were followed for measuring the independent variables.

#### 3.5.1 Age

Age of the farmers was measured in terms of actual years from their birth to the time of the interview, which was found on the basis of the verbal response of the rural people (MoYS, 2012). A score of one (1) was assigned for each year of one's age. This variable appears in item number 1 in the interview schedule as presented in Appendix-I.

#### 3.5.2 Education

Education was measured by assigning score against successful years of schooling by a farmer. One score was given for passing each level in an educational institution (Rashid, 2014). For example, if a farmer passed the final examination of class five or equivalent examination, his/her education score has given five (5). Each farmer of can't read and write has given a score of zero (0). A person not knowing reading or writing but being able to sign only has given a score of 0.5.

#### 3.5.3 Farm size

Farm size of the respondent was measured as the size of his farm (including vegetable and other crops) on which he continued his/her farm practices during the period of study. Each respondent was asked to mention the homestead area including pond, own land under own cultivation, land given to others as borga system, land taken from others as borga system, and land taken from others on lease system. The area was estimated in terms of full benefit to the farmers or his family. The following formula was used in measuring the farm size:

Farm size=A+ B+ 1/2 (C + D) + E

Where,

A = Homestead area including pond,

B =Own land under own cultivation,

C = Own land given to others as borga,

D = Land taken from others as borga,

E = Land taken from others as lease.

The unit of measurement was hectares. The data was first recorded in terms of local measurement unit i.e. ekor or shotok and then converted into hectare. The total area, thus, obtained is considered as his farm size score (assigning a score of one for each hectare of land)

### 3.5.4 Annual family income

The term Annual income refers to the annual gross income of farmer and the members of his family from farming sources. It was expressed in taka. In measuring this variable, total earning taka of an individual farmer was converted into score. A score of one was given for every one thousand taka. This variable appears in item number 4 (four) in the interview schedule as presented in Appendix-I.

### 3.5.5 Land under tomato cultivation

Land area under tomato cultivation of a respondent was measured by total land area of his farm under tomato cultivation last year. Land area under tomato cultivation of a respondent was measured in hectors. This variable appears in item number five (5) in the interview schedule as presented in Appendix-I.

### 3.5.6 Profit from tomato cultivation

Profit from tomato cultivation referred as annual net profit of a respondent from the production of tomato. The profit from tomato cultivation was expressed in Thousand Taka (‘000 Tk). Profit from tomato cultivation was estimated by subtraction of annual expenditure of tomato cultivation from income from tomato cultivation. This variable appears in item number six (6) in the interview schedule as presented in Appendix-I.

### 3.5.7 Yield gap of tomato cultivation

Yield gap of tomato cultivation of a respondent was referred as the difference between the potential farm yield and the actual average farm yield (Uddin, 2009). It was measured in ton/hector. This variable appears in item number seven (7) in the interview schedule as presented in Appendix-I.

### 3.5.8 Professional training experience

Training received by the respondent on tomato cultivation was determined by total number of days of training received by the respondent from any organization on professional training experience. If a respondent took 2 days training on any aspect of rice cultivation from any GOs, NGOs then his training received score would be 2. This variable appears in item number 8 in the interview schedule as presented in Appendix-I.

### 3.5.9 Agricultural extension media contact

It was defined as one’s extent of contact to different communication media related to tomato cultivation. Media contact of farmers was measured by computing media contact score on the basis of their nature of media exposure with ten media. Each farmer was asked to indicate his nature of media contact with four alternative responses, like regularly, occasionally, rarely and not at all basis to each of the ten media and score of three, two, one and zero were assigned for those alternative responses, respectively. Logical frequencies were assigned for each of the four-alternative nature of contact. Media contact of the farmers was measured by adding the scores of ten selected source of information. Thus, media contact score of a farmer could range from 0 to 30, where zero indicated no media contact and thirty indicated highest level of media contact. This variable appears in item number 9 in the interview schedule as presented in Appendix-I.

### 3.5.10 Knowledge on tomato cultivation

Tomato cultivation knowledge of farmers was measured by asking him/her 10 questions related to different components of tomato cultivation. It was all the questions became twenty. The score was given according to response at the time of interview. Answering a question correctly an individual could obtain full score, while for wrong answer or no answer he obtained zero (0) score. Partial score was assigned for partially correct answer. Thus, the knowledge on tomato cultivation score of a farmer could range from zero (0) to twenty (20), where zero indicates no knowledge and twenty indicates highest knowledge on tomato cultivation. This variable appears in item number eleven (10) in the interview schedule as presented in Appendix-I.

### 3.5.11 Causes of yield gap in tomato cultivation

Ten causes were selected and validated by experts to measure the extent of causes of yield gap in tomato cultivation. Five (5) point rating scale was used for each problem. Five alternative responses were not at all, low, medium, high and very high causes. The weights were assigned to these responses as 0, 1, 2, 3 and 4 respectively. Extent of causes of yield gap in tomato cultivation of the respondents was measured by summing up all the responses to all the causes. The extent of causes score could range from 0-40 where '0' indicating no causes and '40' indicating very high causes.

To ascertain the comparison among the respondents a Causes Index (CI) was computed using the following formula:

$$MPFI= P_{vh}*4 + P_h*3 + P_m*2 + P_l*1 +P_n*0$$

Where,

CI = Causes Index

$P_{vh}$= Percent of tomato having very high causes

$P_h$= Percent of tomato having high causes

$P_m$= Percent of tomato having medium causes

$P_l$= Percent of tomato having low causes

$P_n$ = Percent of tomato having no causes

Thus, CI is an item which could range from 0 to 404, where 0 indicated no tomato and 404 indicated very high causes in tomato cultivation.

### 3.6 Measurement of Dependent Variable

"Yield Gap Minimizing Strategies followed by Tomato Growers" was the dependent variable of the study. For measuring the yield gap minimizing strategies of the tomato cultivation, a five (5) point rating scale with 15 strategies were used. The 15 strategies were selected and validated by experts to measure the extent of yield gap minimizing strategies towards tomato cultivation. Five alternative categories to measure the yield gap minimizing strategies towards tomato cultivation were not at all, rarely, occasionally, often, regularly. The score assigned to these responses were 0, 1, 2, 3 and 4 respectively. The extent of tomato yield gap minimizing strategies practiced by the farmers score ranged from 0 - 60, where '0' indicating no practice and '60' indicating highest level of tomato yield gap minimizing strategies. On the basis of extent of tomato yield gap minimizing strategies of the respondents were classified into three categories.

### 3.7 Statement of the Hypothesis

According to Kerlinger (1973), a hypothesis is a conjectural statement of the relation between 2 or more variables. Hypothesis is always declarative sentence form and relate either generally of specifically variables to sentences form and relate either generally or specifically variables to variables. Hypothesis may be broadly divided into two categories, namely research hypothesis and null hypothesis.

#### 3.7.1 Research hypothesis

To find out the relationship between the independent and dependent variables the researcher first formulated research hypothesis. The following research hypothesis was formulated to explore the relationship.

Each of the eleven selected characteristics (age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation) of the farmers has significant contributing factor with their tomato yield gap minimizing strategies.

### 3.7.2 Null hypothesis

A null hypothesis states that there is no relationship between the concerned variables. The following null hypotheses were formulated to explore the relationship.

Each of the eleven selected characteristics (age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation) of the farmers has no significant contributing factor with their tomato yield gap minimizing strategies.

## 3.8 Data Processing

### 3.8.1 Editing

The collected raw data were examined thoroughly to detect errors and omissions. As a matter of fact, the researcher made a careful scrutiny of the completed interview schedule to make sure that necessary data will be entered as complete as possible and well arranged to facilitate coding and tabulation. Very minor mistake was detected by doing this, which were corrected promptly.

### 3.8.2 Coding and tabulation

After completion of field survey, all the data were coded, compiled and tabulated according to the objectives of the study. Local units were converted into standard units. All the individual response to questions of the interview schedule were transferred into a master sheet to facilitate tabulation and categorization.

### 3.8.3 Categorization of data

The collected raw data as well as the respondents were classified into various categories to facilitate the description of the independent and dependent variables. These categories were developed for each of the variable by considering the nature of distribution of the data and extensive literature review. The procedure for categorization has been discussed while describing the variables under consideration in Chapter 4.

## 3.9 Statistical Procedures

The data was analyzed in accordance with the objectives of the study. Qualitative data was converted into quantitative data by means of suitable scoring techniques wherever necessary. The statistical measures such as range, number, sum, mean, standard deviation, frequency, and percentage distribution were used for categorization and describing the variables. Multiple linear regression analysis was done to explore the contributing relationship between the selected characteristics of the farmers with the dependent variable. Statistical package for social sciences (SPSS) version 25 was used for the analysis of data. Five percent (0.05) level of probability was considered as the basis for rejecting any null hypothesis.

# CHAPTER IV

# RESULTS AND DISCUSSION

The findings of the study and interpretations of the results have been presented in this Chapter. These are presented in four sub-sections according to the objectives of the study. The first sub-section deals with the selected characteristics of the farmers, while the second sub-section deals with the extent of yield gap minimizing strategies of tomato cultivation. The third sub-section deals with the contribution of the selected characteristics of the farmers with their yield gap minimizing strategies of tomato cultivation and forth section deals with cause's index have been discussed.

## 4.1 Selected Characteristics of Tomato Cultivars

Eleven characteristics of the farmers were selected to find out their contribution with their yield gap minimizing strategies of tomato cultivars. The selected characteristics included their age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation. These characteristics of the farmers are described in this section.

Data contained in the Table 4.1 reveal the salient features of the characteristics of the farmers in order to have an overall picture of these characteristics at a glance. However, for ready reference, separate Tables are provided while presenting categorizations, discussing and interpreting results concerning each of the characteristics in this chapter.

### 4.1 The salient future of the selected characteristics of the farmers

| Characteristics | Unit of measurement | Possible range | Observed range | Mean | SD |
|---|---|---|---|---|---|
| Age | Year | Unknown | 22-72 | 44.93 | 11.97 |
| Education | Level of schooling | Unknown | 0-18 | 6.31 | 5.46 |
| Farm size | Hectare | Unknown | 0.12-1.30 | .32 | .21 |
| Annual family income | "000" Taka | Unknown | 85-680 | 245.05 | 121.93 |
| Land under tomato cultivation | Hectare | Unknown | 12-90 | 30.91 | 18.56 |
| Profit from tomato cultivation | "000" Taka | Unknown | 15-210 | 42.31 | 34.54 |
| Yield gap of tomato cultivation | Score | Unknown | 10-31 | 18.00 | 5.72 |
| Professional training experience | Days | Unknown | 0-9 | 1.81 | 1.02 |
| Agricultural extension media contact | Score | 0-40 | 8-35 | 21.82 | 6.83 |
| Farmers' knowledge on tomato cultivation | Score | 0-20 | 8-20 | 15.42 | 3.05 |
| Causes of yield gap in tomato cultivation | Score | 0-40 | 16-30 | 24.62 | 2.67 |

#### 4.1.1 Age

The age of the farmers ranged from 22 to 72 year, the average being 44.93 years and the standard deviation was 11.97. On the basis of their age, the farmers were classified into three categories: "young" (up to 35), "middle aged" (36- 50) and "old" (above 50). This distribution was supported by Faruq (2017) shown in the Table 4.2.

**Table 4.2 Distribution of the farmers according to their age**

| Categories according to age (years) | **Farmers** (n=101) | |
|---|---|---|
| | **Number** | **Percent** |
| Young (up to 35) | 27 | 26.73 |
| Middle aged (36-50) | 43 | 42.58 |
| Old (Above 50) | 31 | 30.69 |
| Total | 101 | 100 |

The highest proportion (42.58 percent) of the farmers were middle aged compared to 26.78 percent of them being young and 30.69 percent of the farmers was old. The overwhelming majority (69.31 percent) of the farmers were young to middle aged. Faruq (2017) found almost similar findings. It may due to middle to old aged people have more land ownership than young aged people.

### 4.1.2 Education

The education score of the farmers ranged from 0-18, with an average of 6.31 and standard deviation 5.46. Based on their education scores, the farmers were classified into five categories namely illiterate (0), can sign only (0.5), primary education (1-5), secondary education (6-10) and above secondary (above 10). This distribution was supported by Ahmed (2006) and shown in the Table 4.3.

**Table 4.3. Distribution of the farmers according to their education**

| **Categories according to education (schooling years)** | **Farmers** (n=101) | |
|---|---|---|
| | **Number** | **Percent** |
| Illiterate (0) | 23 | 22.77 |
| Primary level (1-5) | 24 | 23.76 |
| Secondary level (6-10) | 32 | 31.68 |
| Above secondary level (above 10) | 22 | 21.78 |
| Total | 101 | 100 |

It is evident from the Table 4.3 that the highest proportion (31.68 percent) of the tomato farmers had education up to secondary level compared to 21.78 percent of them having above secondary level education. About 22.77 percent of them were illiterate while 23.76 percent of the tomato farmers were primary. Thus, the overwhelming majority (53.46 percent) of the tomato farmers had education ranging from secondary to above secondary level. The findings thus, indicate that the current literacy rate in the study area is higher than that of the national average of 72.60 percent (BBS, 2020). Ahmed (2006) found almost similar findings. Most of the respondents of the locale had primary to secondary level of education and illiteracy rate was low.

### 4.1.3 Farm size

The farm size of the farmers ranged from 0.12 to 1.30 hectares and the mean was 0.32 hectares with standard deviation of 0.21. According to the farm size of the farmers, they were classified into three categories as suggested by DAE (1999) “Marginal (up to 0.2)”, “Small (0.21-1)” and “Medium (1.1-3)”. The distribution of the farmers according to their farm size is shown in Table 4.4.

**Table 4.4 Distribution of the farmers according to their farm size**

| Categories according to farm size (hectare) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| Marginal (up to 0.2 ha) | 22 | 21.78 |
| Small (0.21-1 ha) | 76 | 75.25 |
| Medium (1.01-3 ha) | 3 | 2.97 |
| Large (>3 ha) | 0 | 0 |
| Total | 101 | 100 |

Three–fourth (75.25 percent) of the tomato farmer’s possessed small land compared to 21.78 percent of them having marginal land and only 2.97 percent had medium land possession. The average farm size of the farmers of the study area (.32 hectares) was lower than that of national average (0.60 hectare) of Bangladesh (BBS, 2020). Hasan (2015) found almost similar findings.

### 4.1.4 Annual family income

Annual family income of the farmers ranged from Taka 85 thousand to 680 thousand, the mean being 245.05 thousand and standard deviation 121.93 thousand. On the basis of their annual income scores, the farmers were divided into three categories: “low income” (up to 124), “medium income” (125-366) and “high income” (above 366). The distribution of the farmers according to their annual family income is shown in Table 4.5.

**Table 4.5 Distribution of the farmers according to their annual family income**

| Categories according to annual family income (‘000’ taka) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| Low income (up to 100) | 17 | 16.83 |
| Medium income (101-220) | 66 | 65.35 |
| High income (above 220) | 18 | 17.82 |
| Total | 101 | 100 |

The majority (65.35 percent) of the farmers had medium income compared to 17.42 percent of them having high income and 16.83 percent low income. Thus, the vast majority (82.18 percent) of the farmers had low to medium income, indicating that tomato cultivation is usually practiced by the farmers of comparatively lower economic standings. Dominance of low income farmers may due to poor socio-economic condition, small and medium farm size of the majority farmers. As well as mean annual income of the locale was lower than the national average of $1752 USD may due to more involvement of the farm families in business, services, and getting foreign remittance. Talukder (2006) found almost similar findings.

### 4.1.5 Land under tomato cultivation

The land under tomato cultivation of the respondents varied from 12 to 90 decimal with the mean of 30.91 decimal and the standard deviation of 18.56. Based on the land area under commercial vegetable cultivation, the farmers were classified into three categories (Mean ± 0.5 SD) namely “small land”, “medium land” and “large land” as shown in Table 4.6.

**Table 4.6 Distribution of the farmers according to their land under tomato cultivation**

| Categories | Farmers | |
|---|---|---|
| | Number | Percent |
| Small land (up to 12 de) | 2 | 1.98 |
| Medium land (13-48 de) | 86 | 85.15 |
| Large land (>48 de) | 13 | 12.87 |
| Total | 101 | 100 |

Data presented in Table 4.6 reveals that 1.98% of the farmers in the study area were small land under tomato cultivation, 85.15 % were medium land under tomato cultivation and 12.87 % were large land under tomato cultivation. Land under tomato cultivation shrinks from the total farm size of the respondents. It may due to distribution of farm size for various purposes e.g. homestead area, pond, cultivation of other crops, previous crops and winter vegetables cultivation. Ahmed et al., (2009) found almost similar findings.

### 4.1.6 Profit from tomato cultivation

Profit from tomato cultivation of the respondents varied from Tk. 15 to Tk. 210 thousand with the mean of Tk. 42.31 thousand and the standard deviation of 24.54. On the basis of observed range of profit, the farmers were classified into three categories (Mean ± 0.5 SD) namely "low profit", "medium profit", and "high profit". This distribution was supported by Haque (2006) as shown on Table 4.7.

**Table 4.7 Distribution of the farmers according to their profit from tomato cultivation**

| Categories | Farmers | |
|---|---|---|
| | Number | Percent |
| Low profit (up to 18) | 5 | 4.95 |
| Medium profit (19-66) | 86 | 85.15 |
| High profit (>66) | 10 | 9.9 |
| Total | 102 | 100 |

Data contained in table 4.7 indicate that 4.95% of the farmers had low profit, 85.15% of the farmers had medium profit and 9.90% of the farmers had high profit. The majority of the farmers had medium to high profit which may due to high price of tomato cultivation, availability of storage facilities in the locale and good transport facilities with the capital. Haque (2006) found almost similar findings.

### 4.1.7 Yield gap of tomato cultivation

Yield gap of tomato cultivation varied from 10 to 31 tn/ha with the mean of 18.00 tn/ha and standard deviation of 5.72. Based on yield gap farmers are classified into three categories (Mean ± SD) namely, "low yield gap", "medium yield gap" and "high yield gap". This distribution was supported by Faruq (2017) as shown in Table 4.8.

**Table 4.8 Distribution of the farmers according to their yield gap of tomato cultivation**

| Categories | Farmers | |
|---|---|---|
| | Number | Percent |
| Medium yield gap (upto 13 tn/ha) | 20 | 19.8 |
| High yield gap (14-23 tn/ha) | 61 | 60.4 |
| Very high yield gap (>23 tn/ha) | 20 | 19.8 |
| Total | 101 | 100 |

Data presented in the table 4.8 revealed that an overwhelming majority (60.40%) of the farmers had medium yield gap and 19.80 % of the farmers had low yield gap and 19.80% of the farm high yield gap exists in the locale, which may due to famers' lack of knowledge, education, and low practices of tomato yield gap minimizing strategies. Faruq (2017) found almost similar findings.

### 4.1.8 Professional training experience

The training score of the farmers ranged from 0 to 9 with a mean of 1.81 and standard deviation of 1.02. Based on their observed range, training scores, the farmers were classified into four categories: "no training" (0), low training" (0), medium training" (0), and "high training" (3). The distribution of the farmers according to their training is presented in Table 4.9.

**Table 4.9 Distribution of the farmers according to their professional training experience**

| Categories according to training (no. of days) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| No training (0) | 62 | 61.39 |
| Low training (1-3 days) | 30 | 29.7 |
| Medium training (4-6 days) | 7 | 6.93 |
| High training (above 6 days | 2 | 1.98 |
| Total | 101 | 100 |

About 61.39 percent of the tomato farmers had no training while the 29.7 percent of them received 1-3 days training. Training increases knowledge and skills of the tomato farmers in a specific subject matter area. Individuals who gain high training exposure are likely to be more competent in performing in different activities. But the fact that tomato farmers who received low training, needs attention of the authorities of extension services (GOs and NGOs) in the country. Providing adequate training on appropriate subject matter is likely to increase the knowledge and attitude of the tomato farmers. Hasan (2015) found almost similar findings.

### 4.1.9 Agricultural extension media contact

The observed extension contact scores of the farmers ranged from 8 to 35 against the possible range from 0 to 40, the mean and standard deviation were 21.82 and 6.83 respectively. According to this score, the farmers were classified into three categories: “low extension contact” (up to 15), “medium extension contact” (16-27) and “high extension contact” (above 27). This distribution was supported by Hasan (2015). The distribution of the farmers according to their extension contact is shown in Table 4.10.

**Table 4.10 Distribution of the farmers according to their extension contact**

| Categories according to extension contact (scores) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| Low extension contact (up to 15) | 22 | 21.78 |
| Medium extension contact (16-27) | 55 | 54.46 |
| High extension contact (above 27) | 24 | 23.76 |
| Total | 101 | 100 |

A proportion of 54.46 percent of the farmers had medium extension contact compared to 21.78 percent of them having low extension contact. All most 23.76 percent of the farmers had high contact. Thus, overwhelming majority (78.22 percent) of the farmers had medium to high extension contact. Extension contact is a very effective and powerful source of receiving information about various new and modem technologies. Hasan (2015) found almost similar findings.

### 4.1.10 Farmers’ knowledge on tomato cultivation

Tomato cultivars knowledge scores could theoretically range from 0 to 20. But their observed knowledge scores ranged from 8 to 20, the mean being 15.42 and standard deviation 3.05. Based on the theoretical scores, the farmers were classified into three categories as: “low knowledge” (up to 12), “medium knowledge” (13 to 18), “high knowledge” (above 18). This distribution was supported by Ahmed (2006). The distribution of the farmers according to their knowledge level is shown in Table 4.11.

**Table 4.11 Distribution of the farmers according to their knowledge on tomato cultivation**

| Knowledge level (scores) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| Low knowledge (up to 12) | 15 | 14.85 |
| Medium knowledge (13-18) | 68 | 67.33 |
| High knowledge (above 18) | 18 | 17.82 |
| Total | 101 | 100 |

About 67.33 percent farmers' possessed medium knowledge, 17.82 percent of the farmers possessed high knowledge and 14.85 percent of the farmers had low knowledge. Thus, a proportion of 85.15 percent of the farmers had medium to high knowledge on various aspects of tomato cultivation. Ahmed (2006) found almost similar findings.

### 4.1.11 Causes of yield gap in tomato cultivation

Causes of yield gap in tomato cultivation score of the farmers ranged from 16 to 30 against the possible score of 0-40 with a mean of 24.62 and standard deviation of 2.67. Based on the causes scores, the farmers were classified into three categories: "low causes" (up to 22), "medium causes" (23-26) and "high causes" (above 26). The distribution of the farmers according to their causes is presented in Table 4.12.

**Table 4.12 Distribution of the farmers according to their causes of yield gap in tomato cultivation**

| Categories according to causes (scores) | Farmers (n=101) | |
|---|---|---|
| | Number | Percent |
| Low (up to 22) | 19 | 18.81 |
| Medium (23-26) | 58 | 57.43 |
| High (above 26) | 24 | 23.76 |
| Total | 101 | 100 |

About 57.43 percent of the farmers had medium causes compared to 23.76 percent of them having high causes and 18.81 percent having low causes. Thus, the vast majority (81.19 percent) of the farmers had medium to high causes. Ahmed et al., (2009) found almost similar findings.

### 4.2 Tomato Yield Gap Minimizing Strategies

Tomato yield gap minimizing strategies practiced by the farmers varied from 28 to 55 against the possible range of 0-60 with the mean of 40.96 and standard deviation of 6.23. Based on the extent of practice of tomato yield gap minimizing strategies, farmers are classified into three categories (Mean ± SD) namely, “minimum strategies practiced”, medium strategies practiced” and “maximum strategies practiced”. This distribution was supported by Faruq (2017) as shown in the figure 4.13.

**Table 4.13 Distribution of the farmers according to their tomato yield gap minimizing strategies**

| Categories | Farmers | | Mean | SD |
|---|---|---|---|---|
| | Number | Percent | | |
| Minimum strategies practice (up to 34) | 16 | 15.84 | 40.96 | 6.23 |
| Medium strategies practice (35-46) | 58 | 57.43 | | |
| Maximum strategies practice (above 46) | 27 | 26.73 | | |
| Total | 101 | 100 | | |

Data contained in the table 4.13 indicate that an overwhelming majority (73.27%) of the farmer had practice low to medium level of tomato yield gap minimizing strategies. About 57.43 percent of the farmers had medium tomato yield gap minimizing strategies compared to 26.73 percent of them having high tomato yield gap minimizing strategies and 15.84 percent having low tomato yield gap minimizing strategies. Low annual income, low profit, small farm land, low training, low agricultural extension media contact, lack of knowledge on tomato yield gap minimizing strategies, high problem faced in tomato cultivation and poor socio-economic conditions of the farmers may be the reasons behind minimum and medium level of strategies practiced by them. Faruq (2017) found almost similar findings.

## 4.3 The Contribution of the selected characteristics of the respondents to their farmers' tomato yield gap minimizing strategies

This section deals with the findings exploring the contributing relationship between the selected characteristics of the farmers with their tomato yield gap minimizing strategies. The contributing factors were age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation. The main focus of the study was, "Practice of tomato yield gap minimizing strategies by the farmers".

To assess the contributing relationship between selected characteristics of the farmers with their practice of tomato yield gap minimizing strategies, a multiple linear regression analysis was done. The multiple linear regressions results have been shown in the Table 4.14.

The null hypothesis was, "Each of the eleven selected characteristics (age, education, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, yield gap of tomato cultivation, professional training experience, agricultural extension media contact, farmers' knowledge on tomato and causes of yield gap in tomato cultivation) of the farmers has no contributing factor with their practice of tomato yield gap minimizing strategies."

**Table 4.14 Multiple regression coefficients of the contributing variables related to their yield gap minimizing strategies of tomato**

| Dependent Variable | Independent variable | β | SE | t-value | ρ | $R^2$ | Adj. $R^2$ | F |
|---|---|---|---|---|---|---|---|---|
| Yield gap minimizing strategies of tomato | Age | .008 | .030 | .130 | .897 NS | 0.717 | 0.686 | 8.67 |
| | Education | .228 | .128 | 2.029 | .045* | | | |
| | Farm size | .072 | 3.19 1 | .689 | .493 NS | | | |
| | Annual family income | .016 | .003 | .245 | .807 NS | | | |
| | Land under tomato cultivation | .056 | .033 | .568 | .572 NS | | | |
| | Profit from tomato cultivation | .013 | .019 | .125 | .901 NS | | | |
| | Yield gap of tomato cultivation | -.239 | .096 | -2.724 | .008** | | | |
| | Professional training experience | .174 | .247 | 2.430 | .017* | | | |
| | Agricultural extension media contact | .058 | .122 | .433 | .666 NS | | | |
| | Farmers' knowledge on tomato cultivation | .252 | .239 | 2.157 | .034* | | | |
| | Causes of yield gap in tomato cultivation | -.045 | .116 | -.911 | .365 NS | | | |

** Significant at $p<0.01$; *Significant at $p<0.05$ and Not Significant NS

Table 4.14 shows that there is a significant contribution of the respondents, yield gap of tomato cultivation, education, professional training experience and farmers' knowledge on tomato cultivation. Of these, yield gap of tomato cultivation were the most important contributing factors (significant at the 1% level). Moreover, the data showed that farmer's education, professional training experience and farmers' knowledge on tomato cultivation had also significant contributing factor at ($p<0.05$) 5% level of significance on tomato yield gap minimizing strategies practiced by the farmers while coefficients of other selected variables don't have any contribution to farmers' tomato yield gap minimizing strategies.

The value of $R^2$ is a measure of how of the variability in the dependent variable is accounted by the independent variables. So, the value of $R^2 = 0.717$ means that independent variables account for 71% of the total variation in farmers' yield gap minimizing strategies of tomato. The F ratio is 8.67 which is highly significant ($\rho<0.000$).

However, each predictor may explain some of the variance in respondent's yield gap minimizing strategies of tomato simply by chanced. The adjusted $R^2$ value penalizes the addition of extraneous predictors in the model, but values 0.68 is still show that variance is farmers' yield gap minimizing strategies of tomato can be attributed to the predictor variables rather than by chanced the suitable model (Table 4.14).

In summary, the models suggest that the respective authority may consider the farmers yield gap of tomato cultivation, education, professional training experience and farmers' knowledge on tomato cultivation and in this connection some predictive importance has been discussed below:

### 4.3.1 Significant contribution of yield gap of tomato cultivation to the farmers' yield gap minimizing strategies of tomato

The contribution of yield gap of tomato cultivation to farmers' yield gap minimizing strategies of tomato was measured by the testing the following null hypothesis;

"There is no significant contribution of yield gap of tomato cultivation to the farmers' yield gap minimizing strategies of tomato".

The following observations were made on the basis of the value of the concerned variable of the study under consideration.

a. The contribution of the yield gap of tomato cultivation was at 1% significance level (p=0.008).
b. So, the null hypothesis could be rejected.
c. The b-value of level yield gap of tomato cultivation was (-0.239). So, it can be stated that as yield gap of tomato cultivation increased by one unit, farmers' yield gap minimizing strategies of tomato decreased by 0.239 units. Considering the effects of all other predictors are held constant.

Based on the above finding, it can be said that farmers' have more yield gap of tomato cultivation decreased the farmers' yield gap minimizing strategies of tomato. This implies that with the increase of yield gap minimizing strategies of tomato cultivation of the farmers will decrease their yield gap of tomato cultivation.

### 4.3.2 Significant contribution of education to the farmers' yield gap minimizing strategies of tomato

From the multiple regression, it was concluded that the contribution of education to the farmers' yield gap minimizing strategies of tomato was measured by the testing the following null hypothesis;

"There is no contribution of education to the farmers' yield gap minimizing strategies of tomato".

The following observations were made on the basis of the value of the concerned variable of the study under consideration.

a. The contribution of education was significant at 1% level (0.045).
b. So, the null hypothesis could be rejected.
c. The b-value of education was (0.228). So, it can be stated that as education increased by one unit, farmers' yield gap minimizing strategies of tomato increased by 0.228 units. Considering the effects of all other predictors are held constant.

From the multiple regressions, it was concluded that education of the farmers had third highest positive contribution to their yield gap minimizing strategies of tomato. This implies that with the increase of education of the farmers will increase yield gap minimizing strategies of tomato.

### 4.3.3 Significant contribution of professional training experience to the farmers' yield gap minimizing strategies of tomato

From the multiple regression, it was concluded that the contribution of professional training experience to the farmers' yield gap minimizing strategies of tomato was measured by the testing the following null hypothesis;

"There is no contribution of professional training experience to the farmers' yield gap minimizing strategies of tomato".

The following observations were made on the basis of the value of the concerned variable of the study under consideration.

a. The contribution of professional training experience was significant at 5% level (0.017).
b. So, the null hypothesis could be rejected.
c. The b-value of professional training experience was (0.174). So, it can be stated that as professional training experience increased by one unit, farmers' yield gap minimizing strategies of tomato increased by 0.174 units. Considering the effects of all other predictors are held constant.

From the multiple regressions, it was concluded that professional training experience of the farmers had third highest positive contribution to their yield gap minimizing strategies of tomato. This implies that with the increase of professional training experience of the farmers will increase their yield gap minimizing strategies of tomato.

### 4.3.4 Significant contribution of farmers' knowledge on tomato cultivation to the farmers' yield gap minimizing strategies of tomato

From the multiple regression, it was concluded that the contribution of farmers' knowledge on tomato cultivation to the farmers' yield gap minimizing strategies of tomato was measured by the testing the following null hypothesis;

"There is no contribution of farmers' knowledge on tomato cultivation to the farmers' yield gap minimizing strategies of tomato".

The following observations were made on the basis of the value of the concerned variable of the study under consideration.

a. The contribution of farmers' knowledge on tomato cultivation was significant at 5% level (0.034).
b. So, the null hypothesis could be rejected.
c. The b-value of farmers' knowledge on tomato cultivation was (0.252). So, it can be stated that as farmers' knowledge on tomato cultivation increased by one unit, farmers' yield gap minimizing strategies of tomato increased by 0.252 units. Considering the effects of all other predictors are held constant.

From the multiple regressions, it was concluded that farmers' knowledge on tomato cultivation had third highest positive contribution to their yield gap minimizing strategies of tomato. This implies that with the increase of farmers' knowledge on tomato cultivation will increase their yield gap minimizing strategies of tomato.

## 4.4 Comparative severity among the Causes of yield gap in tomato cultivation

The observed Causes Index of the farmers ranged from 136 to 360 against the possible range of 0-404. Causes Index (CI) of the selected causes is shown in Table 4.15. On the basis of CI, it was observed that "Lack of weather information, early message of weather forecasting" ranked first followed by "Inadequate extension service to support tomato production", "High cost of inputs (seed, fertilizer and pesticides)", "Pressure from middleman to sell produces at lower price" and "Labor shortage (during land preparation, weeding, and harvesting)" were the least causes of yield gap in tomato cultivation.

**Table: 4.15 Causes Index (CI) with Rank Order**

| Statement on problems | Very High | High | Medium | Low | No | Computed score | Rank order |
|---|---|---|---|---|---|---|---|
| Lack of weather information, early message of weather forecasting | 75 | 12 | 10 | 4 | 0 | 360 | 1 |
| Inadequate extension service to support tomato production | 67 | 10 | 12 | 10 | 2 | 332 | 2 |
| High cost of inputs (seed, fertilizer and pesticides) | 46 | 12 | 26 | 13 | 4 | 285 | 3 |
| Pressure from middleman to sell produces at lower price | 39 | 20 | 21 | 16 | 8 | 274 | 4 |
| Lack of quality seed | 38 | 15 | 24 | 20 | 4 | 265 | 5 |
| Scarcity of irrigation (during critical stages of tomato growth) | 27 | 20 | 27 | 20 | 7 | 244 | 6 |
| Lack of storage facilities | 24 | 20 | 31 | 18 | 8 | 236 | 7 |
| Undesirable involvement of middlemen | 16 | 20 | 23 | 15 | 27 | 185 | 8 |
| Depression on sale of lower graded tomato | 13 | 20 | 20 | 17 | 30 | 169 | 9 |
| Labor shortage (during land preparation, weeding, and harvesting) | 9 | 10 | 20 | 30 | 42 | 136 | 10 |

# CHAPTER 5

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Summary of Finding

### 5.1.1 Selected characteristic of the respondents

**Age**

The highest proportion (42.58%) of the farmers were middle aged compared to 26.78 percent of them being young and 30.69 percent of the farmers was old.

**Education**

The highest proportion (31.68%) of the tomato farmers had education up to secondary level compared to 21.78 percent of them having above secondary level education.

**Farm size**

Three–fourth (75.25%) of the tomato farmers possessed small land compared to 21.78 percent of them having marginal land and only 2.97 percent had medium land possession.

**Annual family income**

The majority (65.35%) of the farmers had medium income compared to 17.42% of them having high income and 16.83% low income.

**Land under tomato cultivation**

The only 1.98% of the farmers in the study area were small land under tomato cultivation, 85.15% were medium land under tomato cultivation and 12.87% were large land under tomato cultivation.

**Profit form tomato cultivation**

Only 4.95% of the farmers had low profit, 85.15% of the farmers had medium profit and 9.90% of the farmers had high profit.

**Yield gap of tomato cultivation**

Overwhelming majority (60.40%) of the farmers had medium yield gap and 19.80 % of the farmers had low yield gap and 19.80% of the farm high yield gap exists in the locale.

**Professional training experience**

About 61.39 percent of the tomato farmers had no training while the 29.7 percent of them received 1-3 days training.

**Agricultural extension media contact**

A proportion of 54.46% of the farmers had medium extension contact compared to 21.78% of them having low extension contact.

**Farmers' knowledge on tomato cultivation**

About 67.33% farmers' possessed medium knowledge, 17.82% of the farmers possessed high knowledge and 14.85% of the farmers had low knowledge.

**Causes of yield gap in tomato cultivation**

About 57.43% of the farmers had medium causes compared to 23.76% of them having high causes and 18.81% having low causes.

### 5.1.2 Tomato Yield Gap Minimizing Strategies

Tomato yield gap minimizing strategies practiced by the farmers varied from 28 to 55 against the possible range of 0-60 with the mean of 40.96 and standard deviation of 6.23. Overwhelming majority (73.27%) of the farmer had practice low to medium level of tomato yield gap minimizing strategies.

### 5.1.3 The Contribution of the selected characteristics of the respondents to their tomato yield gap minimizing strategies

Out of 11 selected characteristics of the farmers, yield gap of tomato cultivation, education, professional training experience and farmers' knowledge on tomato cultivation had significant positive contribution with their tomato yield gap minimizing strategies. Of these, Rest three characteristics i.e. age, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, agricultural extension media contact and causes of yield gap in tomato cultivation had no significant contribution with their tomato yield gap minimizing strategies.

### 5.1.4 Comparative severity among the Causes of yield gap in tomato cultivation

The observed Causes Index of the farmers ranged from 136 to 360 against the possible range of 0-404. Causes Index (CI) of the selected causes is shown in Table 4.15.

On the basis of CI, it was observed that "Lack of weather information, early message of weather forecasting" ranked first followed by "Inadequate extension service to support tomato production", "High cost of inputs (seed, fertilizer and pesticides)", "Pressure from middleman to sell produces at lower price" and "Labor shortage (during land preparation, weeding, and harvesting)" were the least causes of yield gap in tomato cultivation.

## 5.2 Conclusions

On the basis of findings, discussion and logical interpretations, the following conclusions have been drawn:

i. Education of the farmers was the most significant contributing factor to their practice of tomato yield gap minimizing strategies. So it could be concluded that education increased knowledge and ability of farmers to understand and response to advance agricultural practices which drove them to adopt advance strategies to minimize tomato yield gap.

ii. Yield gap of tomato cultivation was the most significant contributing factor and negative influence on farmers' practice of tomato yield gap minimizing strategies. In the present study it seemed that low yield gap inspired farmers to follow more advance strategies to obtain higher yield.

iii. Professional training experience was the significant contributing factor on farmer's practice of tomato yield gap minimizing strategies. It can be concluded that participation in different rice cultivation training increased knowledge and skill of the farmers which aware them to adopt different tomato yield gap minimizing strategies to get higher yield.

iv. Farmers' knowledge on tomato cultivation was the significant contributing factor on farmers' tomato yield gap minimizing strategies. It can be concluded that knowledge on tomato cultivation provided up to date information to the farmers which assisted them to minimize tomato yield gap.

## 5.3 Recommendations

On the basis of the findings of the study some recommendations are presented below. Recommendations are divided into two groups- (a) recommendations for policy implications and (b) recommendations for further research.

### 5.3.1 Recommendations for policy implications

i. Farmers practiced strategies which were very common and cheap. So, MoA, DAE, BRRI, BADC and other agricultural organizations should come forward to make available the expensive inputs to farmers i.e. seeds, fertilizers, pesticides, seed treatment fungicides, herbicides, tractor, power tiller, rice weeder, winnower, dryer etc.

ii. Most of the farmers had low and medium level of knowledge on yield gap minimizing strategies and practiced minimum and medium level of strategies. Adequate technical support, training and other instructional activities should be undertaken and continued in order to make them capable of practicing maximum level of strategies.

iii. Education is important for practicing tomato yield gap minimizing strategies. It is therefore recommended that proper steps should be taken to increase the level of education of the old and middle aged farmers to have adequate knowledge on agriculture and proper strategies practiced to minimize yield gap.

iv. Farmers mostly want to get proper suggestions about tomato yield gap minimizing strategies and early forecasting about pests and disease. It is therefore recommended that DAE and other concerned organizations should take special programs to get farmers acquainted with modern practices of tomato yield gap minimizing strategies and advance communication channels.

v. Professional training experience increases farmers' diversified knowledge and make them able to cope with adverse situations. So, policies should be taken to engage farmers with diversified extension media to broaden their outlook and to develop positive attitude on adopting yield gap minimizing strategies. GOs and NGOs can also play a vital role in this regard.

### 5.3.2 Recommendations for further research

i. This study investigated the contribution of eleven selected characteristics of the farmers with their practice of tomato yield gap minimizing strategies. It is recommended that further study should be conducted with other characteristics of the farmers and other dependent variables.

ii. Researcher did not find significant contributing factor of age, farm size, annual family income, land under tomato cultivation, profit from tomato cultivation, agricultural extension media contact and causes of yield gap in tomato cultivation with the dependent variable. In this regard further study may be conducted to justify the contribution of the variables in practicing tomato yield gap minimizing strategies.

iii. Similar studies can be conducted in other high yield gap areas of the country which will be helpful for effective policy implementation.

iv. In this study, only tomato yield gap minimizing strategies aspects were considered. Other major rice, crops like wheat, maize, sugarcane, potato, jute etc. can be considered and research can be conducted.

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## APPENDIX-A

**Department of Agricultural Extension and Information System**

**Sher-E-Bangla Agricultural University, Dhaka-1207**

***An interview schedule for a research study entitled***

**YIELD GAP MINIMIZING STRATEGIES FOLLOWED BY TOMATO GROWERS OF BURICHANG UPAZILA UNDER CUMILLA DISTRICT**

**Sl. No. ………….**

Name of the respondent:

Village: Union:

Upazila: District:

Mobile number:

(Please answer the following questions)

**1. Age**
How old are you?...................... Years

**2. Education**
a) Illiterate……
b) I can sign only……..
c) I read up to class……………
d) I took non-formal education and it is equivalent to class…………….

**3. Farm size**
Please furnish information about your firm size:

| Sl. No. | Land type | Area | |
|---|---|---|---|
| | | Local unit (Decimal) | Hectare |
| 1. | Homestead area including pond (A) | | |
| 2. | Own land under own cultivation (B) | | |
| 3. | Land given to others as borga (C) | | |
| 4. | Land taken from others as borga (D) | | |
| 5. | Land taken from others as lease (E) | | |
| **Total= A+B+1/2(C+D) +E** | | | |

**4. Annual family income**

Please state the income from different sources during the last year:

| Sl. No. | Sources of income | Total price (Tk) |
|---|---|---|
| A. On farm income | | |
| 1 | Agriculture | |
| 2 | Fisheries | |
| 3 | Livestock | |
| B. Off farm income | | |
| 1 | Business | |
| 2 | Services | |
| 3 | Daily labour | |
| 4 | Remittance | |
| 5 | Others (if any) | |
| **Total= (A+B)** | | |

Total annual income =A+B= .........................................Tk

**5. Land area under tomato cultivation**

Please indicate your land area under tomato cultivation...............decimal/bigha/hectare

**6. Income from tomato cultivation**

a) Yearly expenditure for tomato cultivation… ................................. tk.

b) Yearly income from tomato cultivation…......................................tk.

c)Yearly net profit/loss from tomato cultivation (a±b)… ................... tk.

**7. Yield gap of tomato cultivation**

Potential yield (Yp) – Obtained yield (Yb)=Yield Gap (Yg) .............tn/ha.

| Variety | Potential Yield (Yp)* | Obtained Yield (Yb) | Yield Gap (Yg) | Minimizing Strategies |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |

*Potential Yield (Yp) is taken from Upazila Agriculture Office

**8. Professional training experience**

Have you received any training? Yes (……) No (……) If yes, please give the following information:

| **Sl. No.** | **Name of training course** | **Duration of training (Days)** | **Training provider** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| **Total** | | | |

**9. Agricultural extension media contact**

Please indicate the nature of your contact to the following media:

| Sl. No. | Communication media | Extent of Communication | | | | |
|---|---|---|---|---|---|---|
| | | **Regularly (4)** | **Frequently (3)** | **Occasionally (2)** | **Rarely (1)** | **Not at all (0)** |
| | **Personal Contact** | | | | | |
| 1 | Meet with SAAOs (per 3 months) | (≥6) | (4-5) | (3-4) | (1-2) | (0) |
| 2 | Meet with Agriculture Extension Officer (per year) | (≥6) | (4-5) | (3-4) | (1-2) | (0) |
| 3 | Meet with contact growers (per 3 months) | (≥6) | (4-5) | (3-4) | (1-2) | (0) |
| 4 | Meet with ideal farmers (per 3 months) | (≥6) | (4-5) | (3-4) | (1-2) | (0) |
| | **Group Contact** | | | | | |
| 1 | Participation in focused group discussion (FGD) program (per year) | (4) | (3) | (2) | (1) | (0) |
| 2 | Participation in agricultural result demonstration program (per year) | (4) | (3) | (2) | (1) | (0) |
| 3 | Participation in farmers field day (per year) | (4) | (3) | (2) | (1) | (0) |
| | **Mass Media Contact** | | | | | |
| 1 | Listening agricultural program on Radio (per month) | (≥5) | (3-4) | (2-3) | (1) | (0) |
| 2 | Watching agricultural program on Television (per month) | (≥5) | (3-4) | (2-3) | (1) | (0) |
| 3 | Reading agricultural features from printed media (daily newspaper, leaflet, booklet, magazine etc.) | (≥5) | (3-4) | (2-3) | (1) | (0) |
| **Total=(A+B+C)** | | | | | | |

**10. Farmers' knowledge on tomato cultivation**

Please answer the following questions:

| Sl. No. | Questions | Assigned Score | Obtained Score |
|---|---|---|---|
| 1 | Do you know about yield gap? | 2 | |
| 2 | Name 4 HYVs of tomato. | 2 | |
| 3 | Mention 2 major seed treating techniques. | 2 | |
| 4 | Mention 2 special land preparation techniques that help to minimize tomato yield gap. | 2 | |
| 5 | What is the impact of early and delay sowing? | 2 | |
| 6 | Mention 2 optimum period of weeding operation to minimize tomato yield gap (15 DAS, 30/35 DAS and 45/50 DA). | 2 | |
| 7 | What kind of fertilizer should be used for tomato cultivation? | 2 | |
| 8 | Mention 2 major pests of tomato and their control measures. | 2 | |
| 9 | Mention 2 major diseases of tomato and their control measures. | 2 | |
| 10 | Mention 4 major post-harvest activities to store tomato properly. | 2 | |
| **Total** | | 20 | |

**11. Causes of yield gap in tomato cultivation**

Please mention the causes of yield gap related to tomato cultivation:

| Sl. No. | Causes | Extent of cause | | | | |
|---|---|---|---|---|---|---|
| | | **Very High (4)** | **High (3)** | **Medium (2)** | **Low (1)** | **Not at all (0)** |
| 1 | Lack of quality seed | | | | | |
| 2 | Inadequate extension service to support tomato production | | | | | |
| 3 | Lack of weather information, early message of weather forecasting | | | | | |
| 4 | High cost of inputs (seed, fertilizer and pesticides) | | | | | |
| 5 | Labour shortage (during land preparation, weeding, and harvesting) | | | | | |
| 6 | Scarcity of irrigation (during critical stages of tomato growth) | | | | | |
| 7 | Lack of storage facilities | | | | | |
| 8 | Undesirable involvement of middlemen | | | | | |
| 9 | Depression on sale of lower graded tomato | | | | | |
| 10 | Pressure from Middleman to sell produces at lower price | | | | | |
| **Total** | | | | | | |

**12. Yield gap minimizing strategies of tomato cultivation**

Please response to the following tomato yield gap minimizing strategies:

| Sl. No. | Yield gap minimizing strategies | Extent of response | | | | |
|---|---|---|---|---|---|---|
| | | Regularly (4) | Often (3) | Occasionally (2) | Rarely (1) | Not at all (0) |
| 1 | Use of crop calendar | | | | | |
| 2 | Use of quality seed (TLS/registered/certified/ seed of foundation) | | | | | |
| 3 | Seed treatment and use of recommended fungicides (Funagal disease- Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54$^{o}$c for 15 min, Agrimycin 0.025% 12 hour before sowing for bacterial disease) | | | | | |
| 4 | Sowing seed on proper time | | | | | |
| 5 | Maintaining seed rate/bigha/ha | | | | | |
| 6 | Maintaining proper distance of plants | | | | | |
| 7 | Use of recommended weeding (10 DAS, 20/25 DAS and 35/40 DAS) | | | | | |
| 8 | Use of recommended doses of fertilizer | | | | | |
| 9 | Use of IPM | | | | | |
| 10 | Use of mulching | | | | | |
| 11 | Staking and pruning of tomato plants | | | | | |
| 12 | Earthing up of tomato plants | | | | | |
| 13 | Removal of diseased plants | | | | | |
| 14 | Harvesting during maturity stage | | | | | |
| 15 | Following recommended steps of post-harvest operation (cleaning, waxing, grading etc..) | | | | | |
| **Total** | | | | | | |

Thank you for nice cooperation.

……………………………………

Date and Signature of the interviewer