Chapter 1

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) locally known as Karala is one of the important vegetables in South East Asia and especially in India and Bangladesh. It is a commercially important vegetable crop in tropical and subtropical under the family Cucurbitaceae and the Genus *Momordica.* It has a great demand in our country and cultivates largely due to its nutritional and medicinal values compared to other cucurbits (Sarkar *et al*., 1996). In respect of iron and ascorbic acid contents, bitter gourd is a vegetable with immense health benefits due to the presence of medicinal compounds such as charatin, vicine, and polypeptide-p, which play an essential role in lessening the blood glucose levels, thus acts as an essential tonic for diabetic patients (Maurya *et al*., 2018). It has a specific insulin-like protein called polypeptide P that helps to lower blood sugar levels in diabetic patients (The Daily Star, May 13, 2020).

Tindall (1983) reported that 100 g fruit contain about 92 ml water, 25 calories, 1.2 g protein, 0.2 g fat, 5 g carbohydrate, 1.0 g fiber, 13 mg calcium, 32 mg phosphorus, 0.2 mg iron, 0.02 mg thiamine and 0.07 mg riboflavin. According to Maurya *et al*. (2018), not only it is highly nutritional, in addition to, considered a wonder working to health drink. Its juice has innumerable health benefits; in fact, everyone can get benefit out of this juice. Young shoots and leaves are extensively used as vegetable in the Philippines where the plants are found in the wild of waste places. The juices of the leaves and fruits have been used as an anthelmintie, and applied externally for malignant ulcers (Oliver, 1960). According to Ayensu (1984), the leaves are also used traditionally in the treatment of breast cancer. Its leaves are used to clean metals and wash hands and body since they form a slightly soapy solution in water (Dalziel, 1984). Korolla chingrir bhaji and korolla aloo jhol are quite popular dishes in Bengali cuisine. Besides being used in different delectable dishes, the consumption of bitter gourd juice is also very popular.

The development of Bangladesh depends largely on the development of agriculture sector which contributes 14.23% GDP and employs around 40.60% total labor force (BBS, 2018). About 70% the total population lives in rural areas and directly or indirectly depend on agriculture for their livelihood. About 63% labor forces are employed in agriculture of which 57% are employed in the crop sector. In Bangladesh, vegetables are grown in 2.64 percent of cultivable land and annual production of bitter gourd is 52020 metric tons (BBS, 2018). In Bangladesh, the average per capita daily vegetable intake is 56g per day whereas the recommended intake is 250g/day (FAO, 2015). Vegetables not only minimize the malnutrition but also maximize the financial returns. It helps to reduce dependence on rice.

Thus, to fulfill farmers economic demand they are getting more involved in vegetable cultivation along with rice cultivation (Ali and Hauk, 2012).

Bitter gourd is one of the most common fruit vegetables in Bangladesh and has a great demand in Bangladesh. It is cultivated largely due to its nutritional and medicinal properties (Sarkar *et al*., 1996). The yield of these land races is very low. During 2017-18, average yield was 2.19 ton/acre (BBS, 2018) which is much lower than developed countries. It grows round the year but its main growing season is summer. Summer vegetable area usually covers about 40% of the total vegetable area in this country (BBS, 2018). Acreage production of winter vegetables is higher than the summer vegetables. The distribution of the land for vegetable cultivation is not evenly distributed throughout the year. The per capita consumption of vegetable in Bangladesh is about 56g/day, which is the lowest among the countries of South and South Asia. However, the daily per capita requirement is 220g (AVRDC, 2011). There is a big gap between the demand and supply of vegetables in Bangladesh. Hence, improvement of crop yield as well as production of this vegetable crop is most important to mitigate the demand. It has export potentiality because of its excellent keeping quality and grows year-round due to its photo insensitivity (Rashid, 1999).

For Bangladesh, identification of constraints on vegetables production is important to expand it, since the supply of vegetables is quite irregular in most of the Asian countries, including Bangladesh (Ali and Hauk, 2012). Only a small proportion of total cropped areas of Bangladesh is under vegetables production. Most of the agricultural production in Bangladesh is strenuous in rice, occupying about 75% of total cropped areas, whereas only 7% of the total cropped land is used for horticultural crops, including root and tuber crops (BARI, 2017). The area under vegetable cultivation accounts for only 2.63% of the total cropped areas. From this small proportion of the cultivable land area, Bangladesh produces about 40.74 lac metric tons of vegetables annually, of which about 60% are produced in winter and the rest in summer. Therefore, production is not well distributed throughout the year and production for domestic use is relatively scarce in the off-season (BBS, 2018). The area under bitter gourds cultivation is 23890 acres and production are 52020 metric tons and the national average yield is 2.19 ton/acre in Bangladesh (BBS, 2018).

There are two fruit morphotypes of bitter gourd grown in our country. The dwarf plant types produce small sized fruits known as Uchcha and large fruit types called Karalla (Rashid, 1999). There are few varieties, mainly marketed by different seed companies as hybrids. But there are many nameless local varieties/cultivars in the country and their morphological characteristics have not been documented. Exploitation of hybrid vigor is the outstanding achievements of plant breeding. The literature available in plant breeding reveals that the exploitation of hybrid vigor is more feasible in cross-pollinated crops (Shukla and Gautam, 1990). Bitter gourd being a cross-pollinated crop has considerable scope for commercial

exploitation of heterosis. There are wide ranges of variabilities in Bangladesh and there is scope to develop the crop by exploiting the variabilities through collection, evaluation, selection and hybridization (Ahamed *et al*., 2014). In Bangladesh wide range of genetic variability available in bitter gourd but very little attention has been paid for its genetic improvement and commercial cultivation. Having no comprehensive systematic research has been done in this crop in Bangladesh. Present harvestable yield of bitter gourd is very low (5.37 ton/ha) (BBS, 2018) due to unavailability of high yielding varieties. However, bitter gourd is monoecious and highly cross-pollinated in nature. As pollination mechanism can be exploited for commercial hybrid seed production.

In spite of the potential economic and medicinal importance of the crop, due attention has not been given towards the need-based crop improvement programs (Rao, 2017). However, recently the cultivation of bitter gourd has become increasingly popular, because of the growing awareness about the anti diabetic properties and higher nutritive value of this vegetable among the consumers. Due to the efforts of many vegetable breeders, marked improvement in yield has been achieved and a large number of new open pollinated and hybrid varieties have been developed in the recent past (Laxuman *et al*., 2012).

However, cultivation of this multi-purpose and nutrient rich vegetable is most desirable for overcoming the problems of undernourishment, ailments and food poverty especially in the South Asian countries of the world. With current emphasis on consumption of fruits and vegetables to promote sound health and longevity, it is expected that consumption and the demand of bitter gourd must be increased in Bangladesh, and this increase would be matched with an increase in bitter gourd production. Therefore, there is a need to improve the productivity and fruit yield of this vegetable to meet the nutritional and dietary need especially for the rural populations who are the poorest and the most vulnerable to malnutrition and poverty. In this contest, attempt should be made through vigorous breeding program to extend and spread the bitter gourd cultivation at farmer's level.

The preliminary step in all crop improvement programs is the selection of desirable parents. Combining ability is an effective technique for selection and evaluation of parents for crop improvement through hybrid variety development. Singh and Chaudhary (1977), Singh and Joshi (1979) and Srivastava and Nath (1983) conducted diallel studies to identify specific parents and crosses for exploitation of heterosis for fruit yield and some other desirable characters in bitter gourd. The parents that showed high beneficial heterotic effect in their cross combinations can be used in hybrid breeding programs. Selection of parents for hybridization has to be based on the complete genetic information and prepotency of the potential parents. With these points in view, heterosis and combining ability studies are the prerequisite in hybrid breeding programs (Singh *et al*., 2014).

Genetic resources play a pivotal role in its economical utilization and desirable trait improvement. Genetic divergence existing in the population helps in the selection of suitable parents for utilization in Bitter Gourd crop breeding programs. The success of any crop improvement program depends, to a large extent, on the amount of genetic variability present in the population. An understanding of the nature and magnitude of variability among the available genetic stock of a crop is of prime importance to the breeder. Genetic diversity is one of the important tools to quantify genetic variability in both cross and self- pollinated crops (Griffing and Lindstone, 1954 and Murty and Arunachalam, 1966). There is wide genetic variability in Bitter Gourd (Ahamed *et al*., 2014) and thus, the utilization of such variability in the crop's breeding programs is possible. The introduced genotypes have diverse origin and contain many useful traits that are essential for the variety development and in addressing the critical varietal problem of the sector. Variability serves as a reservoir of genetic resource for the plant breeders. The landraces are survived by farmers as well as natural selection by at local environment. As a result, landraces are well adapted to the specific environment. These are widely cultivated throughout the year.

Fruit yield of bitter gourd is a complex trait and governed by many genes or polygenes that is determined by complex associations among several agronomic traits as supported by Chandra *et al*., 1990 and Rao *et al*., 1990. In plant breeding program, direct selection on the basis of morphological characters for yield as such could be misleading. Yield and yield contributing traits like fruit weight, fruit per plant, fruit length, fruit diameter and 100-seed weight, etc. must be taken into consideration for variety development (Masud, 1995 and Rahman, 2006). A successful selection depends upon the information on the genetic variability and association of morpho-agronomic traits with yield. Moreover, path analysis provides a better understanding of the association of different characters with yield.

Exploitation of hybrid vigor is to be outstanding achievements of plant breeding. The literature available in the field of plant breeding reveals that the exploitation of hybrid vigor is more feasible to cross-pollinated crops than self-pollinated ones (Shukla and Gautam, 1990). Being a cross-pollinated crop, bitter gourd has a considerable scope for commercial exploitation of heterosis and virtually obligatory out crossing system has opened the scope for the development of hybrid variety. The term heterosis was first coined by Shull (1910) signified increased or decreased vigor of the F_1 hybrids over the parents. This phenomenon referred the stimulus heterozygosis and the expression of heterosis may be due to factors such as heterozygosity, allelic interaction such as dominance or over dominance, non-allelic interaction or epistasis and maternal interactions (Shull, 1948).

Gaining knowledge on gene action is very important where progress from selection depends primarily on the additive gene action and dominance on the other hand could be effectively utilized in the production of hybrid variety development (Hasanuzzaman, 2010). If over

dominance exhibited, it would be worthwhile to use a heterosis breeding method. Therefore, for initiating effective heterosis breeding program in bitter gourd one needs to elucidate the genetic nature and magnitude of quantitatively inherited various traits and estimated prepotency of parents in hybrid combinations. The combining ability studies like diallel analysis provides information in this direction. The general combining ability (GCA) effects help in selection of superior parents for hybridization while specific combining ability (sca) effects help in selection of superior hybrids. The information generated in the process will be helpful to understand the magnitude of heterosis in F_1 hybrids (Aruah *et al.*, 2012, Sivakami *et al*., 1987, Maurya *et al.,* 1993 and Kumar, 2000). Correlation alone does not give exact contributions of the various characters on the fruit yield; hence path analysis would help in partitioning the correlation coefficient into direct and indirect effects of various traits on the fruit yield.

A systematic breeding program is always required for enhancement in its yield potential and other horticultural traits in bitter gourd (Kumar *et al.,* 2018). In Bangladesh, Agricultural Research Institute has the bitter gourd improvement program which is basically based on selection. On the other hand, very few private seed companies have hybrid variety development programs. They also follow selection and hybridization without following full breeding procedures. Efforts to improve the crop have been constrained to mainly in on lack of adequate information on the genetic studies on the yield and yield related traits of Bangladeshi bitter gourd landraces. Academic research on bitter gourd in Bangladesh is not available but public research organizations conduct minimum works on breeding related activities due to shortage of plant breeders in breeding related works and lack of knowledge of information on yield and yield related traits.

Understanding the inheritance of yield and yield related traits in advance would be supportive to maximize the use of genetic potential in an effective breeding program. In bitter gourd, such genetic information in Bangladeshi genotypes is rarely available limits to the planning of a sound breeding program to improve the basic yield and associated traits of the crop. Very few studies have been so far conducted to find the genetic analysis of yield and yield related traits in bitter gourd. Hence, enhancement of yield is still an important goal for the bitter gourd breeders in Bangladesh. The F_1 offers several advantages like earliness, high yield, improved quality, uniformity in the mass productivity, wider adaptability and also helps in deployment of dominant genes for resistance to diseases and pests (Rajendran, 1961 and Pitchaimuthu and Sirohi, 1994). Developed countries like USA, Canada, Japan, Korea etc., have been producing the hybrids in almost all vegetables. But Bangladesh is still lacking much behind in this aspect. To develop a variety, knowledge of genetics and plant breeding for the improvement of the traits is essentials but this information is not available in case of

bitter gourd. It is a monoecious and highly cross-pollinated crop and has been known to offer good potentialities for increased yield (Verma *et al*., 2013).

Choice of parents considered as an important aspect in any breeding program aimed at improving the yield and its related attributes. Line X tester analysis helps in the selection of desirable parents. Success of any plant breeding program depends on the choice of appropriate genotypes as parents in the hybridization program. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Line X tester technique (Kempthorne, 1957) is useful in deciding the relative ability of lines to produce desirable hybrid combinations. Line x tester analysis provides information about general combining ability (GCA) effects of parents. It also provides information on genetic components and enables the breeders to choose appropriate breeding methods for hybrid variety development programs. The information obtained thus will be used in selection of suitable parents and choice of appropriate breeding methods to develop high yielding hybrid variety (Singh and Kumar, 2004). However, to breed high yielding varieties, the breeders often face the problem of selecting parents. In this context, various breeding approaches have been suggested. The line X tester analysis method is one of the powerful tools available to estimate the combining ability effects and aids in selecting desirable parents for exploitation in breeding (Fellahi *et al*., 2013). Singh and Kumar (2004), Rashid *et al.,* (2007) also identified suitable parents through line x tester analysis.

Therefore, considering the situation, importance of bitter gourd, the availability of genetic variability, its scope of yield improvement and export potential, the present investigation was undertaken with the following objectives:

1. To screen the inbred lines for yield and yield contributing traits
2. To find out the important yield contributing traits
3. To study the combining ability of the parental lines
4. To select the best cross combination based on estimates of heterosis for hybrid variety development in bitter gourd