

STUDY ON YIELD AND QUALITY OF DIFFERENT BER (*Zizyphus mauritiana* Lamk.) CULTIVARS

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BER (*Zizyphus mauritiana* Lamk.) CULTIVARS**

By

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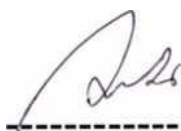
A Thesis

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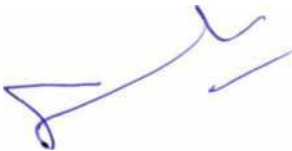
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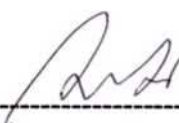
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CERTIFICATE

This is to certify that the thesis entitled “**STUDY ON YIELD AND QUALITY OF DIFFERENT (*Zizyphus mauritiana* Lamk.) CULTIVARS**” submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE** embodies the result of a piece of authentic research work carried out by **MUHAMMAD SHAHINUL ISLAM, REGISTRATION NO.26131/00430**, under my supervision and guidance. No part of this thesis has been submitted for degree in any other institutions.

I further certified that any help or sources of information, received during the course of this investigation have been duly acknowledged.

Dated: June 30, 2007 Dhaka, Bangladesh.



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Dedicated to
My
Beloved Parents

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The Author

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By

Muhammad Shahinul Islam

ABSTRACT

An experiment was carried out at the Fruit Research Station, Binodpur, Rajshahi during the period from August 2006 to March 2007, to evaluate the fruit quality and yield of twelve ber cultivars viz. Apple kul, BARI kul 1, BARI kul 2, Chapai kul, Dhaka- 90 kul, Hazari kul, Khulna kul, Myanmar kul, Nabhi kul, Off season kul, Sabji kul and Zahazi kul. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The results of the experiment indicated that the cultivar Dhaka-90 kul produced the biggest fruits(45.17g) and Apple kul produced the smallest fruits (13.00g). Apple kul produced fruits having desirable fruit shape and size, attractive apple colour, highest TSS (15%) value, high market demand etc. The highest shelf life was also observed in Apple kul (5 days) and lowest in Chapai kul (3 days). Maximum number of fruit per plant (3776) was found in Apple kul and the lowest in Dhaka-90 kul (1938). Dhaka- 90 kul produced the highest yield (24.25 t/ha) where as Chapai kul, Hazari kul and Nabhi kul produced the lowest yield (12.50t/ha). On the other hand Dhaka-90 kul is higher yielder but less preferred by the consumer due to its undesirable fruit size and shape and less attractiveness. Based on attractiveness of fruits, market demand, fruit colour and sweetness, Apple kul was the best cultivar among those for commercially cultivation in Bangladesh.

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ACRONYMS AND ABBREVIATIONS

Full word	Abbreviation
And others	<i>et al.</i>
Bangladesh Agricultural Research Institute	BARI
Centimeter	Cm
Coefficient of variation	C V
Cultivar	cv.
Degree Celsius	°C
Dry weight	DW
Duncan's Multiple Range Test	DMRT
Et cetera	etc.
Figure	Fig.
Fresh Weight	F W
Gram	G
Hectare	Ha
Hour	h
Journal	J
Kilogram	Kg
Metre	M
Mean sum of square	MSS
Millimetre	Mm
Namley	Viz.
Number	No.
Randomized Complete Block Design	RCBD

Chapter I

Introduction

CHAPTER I

INTRODUCTION

The ber or jujube (*Zizyphus mauritiana* L.) commonly known as ‘boroi’ or kul in Bangladesh, is one of the most ancient common fruits of Indian subcontinent (Yamgani, 1985). It is found to grow in cultivated forms practically all over the country. The centre of origin of ber is in Burma and British India (Decandolle, 1986). The ber under the family Rhamnaceae is high valued popular fruit grown all over the country (Hoque, 2002). Ber has about 50 genera and more than 600 species (Pareek, 1983). Bhansli (1975) stated that the genus *Zizyphus* consists of 135 species of which nearly 90 are found in the old world and 45 species are confined to the new world. He has described 28 species found in various regions of India.

In the year 2002 to 2003 (BBS, 2004) Bangladesh produced 4453 tons of ber fruits from 4858 hectares of land. The per hectare yield was 25 tons. The ber fruits are also growing in India, Pakistan, Sri-Lanka and Thailand.

The ber plant is quick growing , early bearing and spreading tree. The tree flowers in autumn and fruits mature at the end of winter. It is cross pollinated crop and often propagated through seeds resulting variabilities in quantitative and qualitative characteristics of fruits (Hoque, 2002). Most of the ber plants are in homestead areas. Ber cultivation requires least inputs and care. It has a remarkable adaptability enabling it to grow in wide range of agro-climatic situations and soils. It can also grow in slightly alkaline or waterlogged soils.

Being a hardy plant it can be grown even on inferior and marginal lands and can tolerate dry and hot climate. It responds well to manuring, irrigation, training and pruning .

The fruits are very popular for its sweet-sour taste. It comes to the market mostly in February to March when there is a scarcity of local fruits. So the growers get handsome cash from these fruits. According to Rashid *et al.* (1987) ber cultivation is more rewarding than many other fruits. Its cultivation in recent years attained so much popularity among the fruit growers that it is no more considered a “poor-man’s” fruit. The ber fruit contains 20-28% sugar, 0.3-2.5% acid, 2.9% protein, 500 to 600 mg vitamin C/100g pulp and very high quality of vitamin B complex (Kuliev and Guseinnova, 1974). The Indian ber is grown chiefly for its fruits which may be eaten fresh, dried or candied or canned smoked pickled or used in drinks. Several products like ber butter, ber squash or juice, ber murabba, ber pulp, ber jam and dehydrated or dried products may also be made from ber fruits (Pareek, 1983; Yamgani, 1985; Anon, 1986). Various Ayurvedic and Yunani medicine contain ber extract which is said to be blood purifier and also help in digestion. The medicinal value of various parts of the tree and fruits of *Zizyphus mauritiana* (L.) are many and yet not fully exploited. Ber tree is important host plant for insect *Laccifer lacca* (Kerr) which secretes a resinous substance on the twigs which is the raw materials for Shellac preparation.

The ber plant yields a heavy crop every year. The fruit can be harvested within two years of budding *in situ*. The wild ber trees can be made more productive by top working with better cultivars after harvest and one can get desired fruit in the following seasons. In spite of the fact that ber cultivation is rewarding, there has not been much effort to extend its area or improve its quality in Bangladesh. As such variability exists among the cultivars both in quantity and quality of fruits. Quality ber are mostly cultivated in Rajshahi, Nowgaon and Shatkhira.

The ber is minor but popular fruit in Bangladesh. There are many cultivars cultivated all over the country. But information on yield, quality and other characteristics is scanty. The yield and quality of fruits of ber cultivars varies from cultivar to cultivar. So cultivation of any cultivar may not be profitable. It is necessary to know about different ber cultivars and to determine what cultivar is to be commercially cultivated. So it has a great deal for critical evaluation of the available cultivars and selection of the improved cultivar(s) with yield potential and quality. Therefore the present study has been undertaken with the following objectives:

1. to find out the yield of different ber cultivars
2. to determine the characteristics of fruits
3. to know the quality of fruits
4. to determine better cultivar(s) for recommendation

Chapter II

■ Review of literature

CHAPTER II

REVIEW OF LITERATURE

The research works related to different aspect of ber (*Zizyphus mauritiana* L.) cultivars had been done on different aspects of ber in different parts of the world including Bangladesh but unfortunately literature regarding the studies on the yield and quality of fruits of ber cultivars were scanty. The available literatures related to the present studies were reviewed in the following heading.

2.1 Yield of ber

Yield and characteristics of fruits of eight budded ber plants were recorded by Rahman *et al.* (2006-2007) during the fruiting season of (2006-2007). The result showed that the highest fruit yield/plant (41.00kg), average weight (40g) were obtained from ZM -054. Maximum number of fruits/kg (116) and fruits/plant (3538) were recorded from ZM -053.

A study was conducted by Islam (2005-2006) at the Fruit Research Station, Binodpur, Rajshahi with eleven local and one exotic ber varieties during November 2005 to March 2006. Dhaka-90 kul produced the maximum weight of the fruit (42.38g) and it was minimum in Off season bearing kul (9.52g). The highest total soluble solids (15%) was recorded in Apple kul and BARI kul-1 while it was the lowest (10%) in Chapai kul and Off season kul. The Dhaka -90 kul gave the highest yield (21.73 t/ha) followed by Myanmar kul (19.50 t/ha) and it was the lowest in Chapai kul (9.44 t/ha).

Hoque (2002) conducted an experiment on variabilities in ber fruits of Dhaka region. The result showed a great variation among the genotypes on fruit weight. The eight of fruits varied from 4.72g to 21.20 g .The fruits of all the accessions were more than 11.0g in weight except a few which were 4.72g (ZJ05), 7.80g (ZJ06), 8.72g (ZJ11) and 9.32g (ZJ15). The length and diameter of fruits also varied from 2.40cm to 4.66cm and 2.00cm to 3.46 cm, respectively.

Dinesh *et al.* (2001) conducted an experiment during 1998-99 and 1999-2000 in Agra, on 20 to 22 year old ber (*Zizyphus mauritiana* L.) cultivars Alliganj, Banarasi, Gola, Jogia, Kankar, Kalan, Karaka, Muria Mahrara, Narma, Ponda, Sofeda, Suanund and Umran to evaluate the performance. The highest tree height (6.49 m) was recorded in Jogia followed by Umran (6.32 m) and Narma (6.30 m). The highest tree girth

'X

(29.22 cm) and tree volume (102.67 cm) were recorded in Alliganj. Ponda Sofeda gave significantly higher fruit yield (33.33 kg/plant) compared to the other cultivars.

Aulakh *et al.* (2000) investigated that three cultivars of ber {*Zizyphus mauritiana* L.) Sanaur-2, Umran and ZG2 grown at Regional Research Station, Ballawal Shunkhri, Panjab, India during 1995-96, were evaluated for fruit yield, growth characteristics and physiochemical properties. Results revealed that Sanaur-2 was the most promising for cultivation under rainfed conditions in the lower Shiwaliks of Panjab having the highest values for almost all of the evaluated parameters and

fruit yield of 32.3 kg/plant, which were significantly higher than Umran (13.0 kg/plant) and ZG2 (11.2 kg/plant). Rudreshappa *et al.* (2000) conducted a field experiment in Dharwad, Karnataka, India in 1997 and 1998 to evaluate the performance of seven *Zizyphus mauritiana* cultivars (Kadaka, Chhuhar, Sanaur-2, Dandan, Salnaur-6, Jolgia-Mundia and Umran). Jolgia-Mundia produced the tallest plants (5.60 m) while Sanaur-6 showed the highest number of primaries (82.08). The highest yield (137.65 quintal/ha and 118.45 quintal/ha) and total soluble solids content (22.15 and 19.81 %) were recorded for Dandan and Umran.

Praveen and Patil (1998) conducted a field experiment at Raichur on 4 years-old trees. Twelve popular ber cultivars were compared in this study. Data were tabulated on plant height, plant spread, canopy volume, length of secondary branches, number of tertiary branches, stem girth, number of fruits per plant and fruit yield. Fruit yield was highest in cv. Sanuar-2 and lowest in Rambore.

Reddy (1998) observed that *Zizyphus mauritiana* L. is becoming more widely grown due to its adaptability to drought and tolerance of marginal land. The results of an economic analysis of cost and return were carried out to determine the most profitable cultivar. The performance of 11 cultivars was monitored at Dharwad, Karnataka, India, during 1989-95. Results showed that Dandan, Sanaur-2 and Chhuhara, with mean fruit yield of 6.78t/ha, 6.36t/ha and 6.08 t/ha, respectively,

Reddy *et al.* (1997) conducted a field experiment at Anantapur, India during 1990-91 to study the influence of land treatment (flat bed or basins with a 5 % catchments slope) and plant population (278, 185,139 and 111 plants/ha) on fruit yield of *Zizyphus mauritiana* cv. Gola under rainfed

conditions. In 1990, the highest yields (1989-4863 kg/ha compared with 1676-4004 kg/ha) were produced by plants planted in basins. However, in 1991, plant on flat beds produced the highest yield (Mean value of 1913 compared with 1684 kg/ha). The highest yield was observed at highest planting density. No interaction was observed between land treatment and plant population. Tiwari (1995) also reported that fruit weight and yield were highest in cv. Gola when planted at a spacing of 4.8 m x 4.8 m.

Reddy *et al.* (1995) investigated the eleven cultivars budded onto local rootstocks and compared in trials at Gangavati over 3 years. Fruit yields ranged from 3.27kg/tree in cv. Illaichi to 19.49 kg/tree in cv. Sanuar-2. Fruit quality was also scored and found highest in cv. Chhuhara. It was concluded that cultivars Sanuar-2, Sanuar-6, Dandan, Chhuhara and Kadaka showed promise for N. Karnataka due to their drought tolerance and yielding abilities.

Bajwa *et al.* (1972) recommended 10 kg farmyard manure plus 0.5 kg ammonium sulphate per year per plant and stabilizing the dose at 5 years age. The average yield of different varieties during the prime bearing age of about 10 to 20 years ranged between 80kg and 200 kg fruits per tree (Bakhshi and Singh, 1974).

2.2 Quality of fruits

Rahman *et al.* (2006-2007) reported that the size of fruit of ZM- 054 was larger but taste was not good. In respect of fruit shape, skin colour, sweetness, taste and TSS(%), good quality fruits were obtained from ZM -038, ZM-004 and ZM-053.

Islam (2005-2006) conducted an experiment at the Fruit Research Station, Binodpur,Rajshahi with eleven local and one exotic ber cultivars during November 2005 to March 2006. The result indicated that the highest total soluble solid (15%) was recorded in Apple kul and BARI kul -1 while it was the lowest (10%) in Chapai kul and Off season kul.

An experiment was conducted by Jat *et al.* (2004) during two consecutive years in different cultivars of ber i.e. Gola, Chumu local, Seb, Umran, Kaithli and Mundia. Observations were recorded at four stages, i.e. prematurity (November), half maturity (December), maturity (January) and harvesting stage (February). The result showed that fresh fruit weight increased continuously in all the cultivars. It was maximum in Umran and minimum in Chumu local. The increased in fruit weight was recorded continuously from November to February in all the cultivars, however, at variable magnitude. The fruit length and width were enhanced and significant variation in cultivars for this parameter was recorded at final harvest. The change in water content in different stages, in general, was non significant in all the cultivars. Sugar, protein and TSS increased continuously but differed significantly among cultivars. The variation in the rate and capacity of dry matter accumulation was noticed by measuring the pulp: stone ratio.

Ten ber cultivars {*Zizyphus mauritiana* L.) i.e., Delhi, Sufaid, Bahawalpur selection-1, Alu Bukhara, Karaila, Umran, Bahawalpur selection-2, Mahamoodwall, Gorh, Sufan and Khobani were evaluated for yield and fruit traits under the semi arid conditions of Bahawalpur district of Panjab, Pakistan during 2000-2002. It was reported that Delhi Sufaid was superior in terms of fruit yield (206-252 kg per tree), total soluble solid content (23-24%), sugar content (9-10%), length and breadth (4x4 cm), but ranked second in terms of fruit weight (30-31 g) and pulp weight (28-29 g). Bahawalpur selection -1 had the greatest fruit weight (32-33 g) and pulp weight (29-30 g) and ranked second in terms of fruit yield (185-203 kg per plant). Mahamoodwali fruits were the most aromatic, whereas Gorh fruits exhibited superior keeping quality (Mushtaq *et al.*, 2003).

Hoque (2002) studied on variabilities in ber fruits of Dhaka region. The result showed that fruits colour at maturity varied from deep green to reddish. The fruits of the accession ZJ01 ,ZJ03-ZJ10,ZJ12 and ZJ14 were deep green to light green in colour where as the fruits of ZJ02, ZJ11 and ZJ13 were reddish but ZJ15 were brownish. Flesh color of fruits of all the accessions were whitish except those of ZJ02, ZJ03, ZJ11 and ZJ13 which were slightly reddish. The fruits were graded into five groups - very sour, sour, slightly sour, sweet and very sweet. The fruits of accession ZJ07 and ZJ12 were very sweet while those of ZJ01 ZJ08,ZJ09 and ZJ10 were sweet in taste and the rest were sour to very sour except the fruits of ZJ13 which were sweet but slightly bitter in taste. Fruits of all the accessions were crispy in texture except the fruits of ZJ05 and ZJ06 which were loose textured. The plants of ZJ11 produced hard textured fruits.

Pareek *et al.* (2002) studied on eight *Zizyphus mauritiana* (L.) genotypes (Gola, Seb, Umran, Mundia Illaicha, Tikadi, Jogiya and Bagwadi) and three local selection of *Zizyphus rotundifolia* (local 1, 2 and 3) and were evaluated for their performance in Jobner, India during 1999-2000. Gola, Seb and Umran showed more vigorous growth compared to others.

The longest fruit (3.87 cm) was observed in Mondia while Seb had the highest fruit breadth (2.9 cm). Umran had the highest fruit weight (17.29 g). Ascorbic acid content was in the range of 36.96mg/100g -1674.90 mg / 100 g with the lowest and highest value in local-3 and Bagwadi, respectively. Gola showed the best height, spread, yield and acidity. Jogiya was the sweetest testing cultivar with the highest total soluble solids content.

Chowdary and Padashetty (2000) conducted an experiment to determine the biochemical composition of some ber (*Zizyphus mauritiana* L.) cultivars grown under the agro climatic condition of Karnataka, India. Evenly matured fruit samples from different ber cultivars (Umran, Gola, Seb, khaithal and Chhuhara) and a wild variety were collected, washed and analysed. The maximum amount of total soluble solids (TSS) was recorded in Khaithali (18%) which was closely followed by Umran (17 %). The minimum TSS (12%) was recorded from the wild variety. Acidity was 0.19% in Umran and 0.63% in Khaithali. Ascorbic acid content varied from 50 mg/100 g in the wild variety to 121 mg /100 g in Khathaili. The total sugar and reducing sugar ranged from 6.1% and 2.0% to 14.0% and 4.1% in the wild variety.

Fruits of five ber (*Zizyphus mauritiana* L.) cultivars, Umran, Sanaur-2, Gola, Seb and Kadaka were evaluated for morphological and physicochemical characteristics recorded by Shobha *et al.* (2001). Sanaur- 2 had higher total soluble solids (TSS) among the cultivars. The highest moisture content was in Kadaka. Sanaur-2 and Gola had higher acidity compared to the other cultivars. Gola and KAdaka had higher β -carotene contents than the other cultivars. Non reducing and total sugars were highest in Umran.

Rahman (1999) conducted an experiment on fruit morphology and nutritive value of some selected jujube (*Zyziphus mauritiana* L.). The average weight, length and diameter of fruit were ranged from 10.52 g to 46.00 g , 2.87 cm to 5.58 cm and 2.50 cm to 4.20 cm, respectively. He also recorded the average weight, length and diameter of seed which ranged from 0.85 g to 2.88 g, 1.60 cm to 3.18 cm and 0.79 cm to 1.27 cm, respectively. Seed-pulp ratio recorded from 1: 08.61 to 1: 21.63. Largest fruit was recorded in Dhaka-90 kul. Apple kul was superior to others due to its earliness, sweetness and attractive apple colour. The ascorbic acid (Vitamin-C) content in jujube fruit ranged between 50.50 and 101.75 mg per 100 g pulp. The quantity of ascorbic acid was recorded maximum in Dhaka-90 kul and minimum in Zahazi kul.

An experiment was initiated at HRC, Gazipur in 1996. Quantitative and qualitative characters of fruits of six ber plants were recorded by Islam *et al.* (1996) during fruiting season in January to March 2004. Among the six ber lines, ZM-053 and ZM-009 were found to be promising in respect of fruit quality.

Mastana *et al.* (1995) conducted an experiment on quantitative and qualitative performance of 10 different cultivars of ber in India. Data were collected for mean fruit weight, % pulp, fruit diameter, fruit length, total soluble solids (TSS) and mean quality score. Results showed that cultivar Rambhor had the highest stone to pulp ratio (1:32.58) compared to others. Cultivar Manukki (1:8.23) had the lowest. TSS content was the highest in Illaichi (22.8%) and the lowest in Sanaur-2. Dandan, Chuhara and Kadaka were superior in terms of fruit yield and quality. Reddy *et al.* (1995) observed that the maximum pulp and TSS were recorded for Seb, Banarasi and Karaka, whereas maximum acidity, moisture content and seed coat were recorded for Gola. Banarasikaraka had maximum sugar content (10%), sugar recovery (5%), vitamin C (73mg/100g pulp), P (0.30%) and Ca (2.5%) in the fruit. More vitamin C was found in the fruit flesh near the center than close to the skin and in the upper part rather than the styler end. It is concluded that Banarasi karaka is superior to Seb and Gola in terms of nutritive value.

Quadir and Hossain (1995) noted the physical attributes of jujube fruits like length of fruit 3.38 cm, diameter of fruit 2.89 cm, length of stone 1.96 cm, diameter of stone 0.83 cm, whole fruit weight 15.41 g, stone weight 1.89 g (12.3 %) and edible tissue weight 13.52 g (87.7 %).

Yu *et al.* (1991) described the characteristics of the seven jujube varieties in China. According to authors, Li Zao fruits were early and gave high stable yields of good quality fruits containing 23.1 per cent sugar, 0.37 per cent organic acids and 287.91 mg ascorbic acid per 100 g fresh fruit. Jixin Mi fruit contained 27.69 per cent sugar and 0.59 per cent acids. Buluosa fruits contained 24.7 per cent sugar, 0.41 per cent acids and 247.21 mg ascorbic acid per 100 g. Lingling Zao fruit contained 28.71 per cent sugar, 0.57 per cent

acids and 251.21 mg ascorbic acid per 100 g. Xiangfen Hulu Zao fruit contained 56.12 per cent sugar and 1.98 per cent organic acid. Yongji Hama fruit contained 26.7 per cent sugar and 0.42 per cent organic acids.

Ber was found to contain 85.9 per cent water, 0.8 per cent protein, 0.1 per cent fat, 12.8 per cent carbohydrate, 0.03 per cent calcium, 0.03 per cent phosphorus, 0.8 per cent iron and 50-150 mg vitamin C per 100 g edible portion (Mondal and Amin, 1990).

Latiff (1989) observed that the jujube fruit was globose to ovoid, smooth or rough, glossy, thin but tough, yellowish to reddish or blackish; white fleshed, crispy, juicy and subacid to sweet in taste. Seed was a tubercled and irregularly furrowed stone. Fruits of var. *mauritiana* were ovoid, 2.5-3.5 cm long and those of var. *spontanea* fruits are globose, 1-cm diameter. He also stated that 100 g edible portion of jujube grown in India contained water 86 g, protein 0.8 g, fat 0.1 g, carbohydrates 12.8 g, calcium 30 mg, phosphorus 30 mg, vitamin A 70 IU and vitamin C 50- 150 mg but Thailand jujube contained 71.05 g water, 0.7 g protein, 1.7 g fat, 23.7 g carbohydrate, 30 mg calcium, 30 mg phosphorus, 50 IU vitamin A and 23 mg vitamin C.

A study was conducted by Bal *et al* (1988) on fruit and seed characters of 'Umran' jujube. They observed fruit which was 3.80 g in weight, 43.6 mm in length and 31.5 mm in diameter. Stone was 1.54 g in weight and 10.2 mm in diameter.

Bisla and Daulat (1988) carried out an experiment on ten years old plants of 30 *Zizyphus maritiana* L. cultivars at Hissar during 1980-82. High variability was observed for all fruits and seed characters studied. Heritability was high for fruit weight (97.2%) and fruit size (87.9 %), pulp: stone ratio (87.5 %) and seed weight (84.6%).

Kumar and Babu (1987) investigated seven cultivars grown at Hyderabad under semi- arid tropical conditions. Mundia was the highest yielder (116.1 kg) followed by Umran and Gola. Mundia also had the largest fruit while those of Umran had medium sized. It also contained the highest percentage of total soluble solid (18.5%) and sugar (8.9%). The TSS and sugar level were relatively higher in Gola and lower in Mundia. Umran and Gola were recommended for cultivation in Hyderabad and the surrounding areas. Babu and Kumar (1986) also observed that Umran produced the heaviest fruits (29.7 g).

According to Rashid *et al.* (1987), jujube fruits contained 80 per cent water, 1 per cent protein, 0.3 per cent fat, 18 per cent carbohydrate, 0.5 per cent mineral matter and 50-150 mg vitamin C/100 g fruit.

According to Bhatia and Gupta (1985), the jujube of Gola cultivar contained 16.7-17.0 per cent TSS, 0.20-0.24 per cent acidity but TSS- acidity ratio was 76-84 at maturity.

According to Pareek (1983a), the styler end of fruit of cultivar 'Ilaichi' was round, 'Delhi gola' was roundish; 'Badshah pasand' and 'Banarsi' were slightly tapering, 'Choara chhuhara' was slightly depressed and 'Banarsi pewandi' was slightly pointed.

Pareek (1983b) reported that the stem end of cultivar 'Choara chhuhara' and 'Chonchal' were round; 'Ilaichi' was flattened; 'Bekata varanasi' was depressed; 'Glory' was tapering; 'Deshi Alwar' was ridged and 'Badshah pasand' was obtuse.

Singh *et al.* (1983) reported that the fruits of jujube cv. Umran and Gola contained 8.1 and 8.05 per cent total sugar, respectively.

According to Pareek (1983c), several cultivars of jujube contained 93-97 % pulp, 81 % moisture, 3.5-4.7 % seed, 13-20 % TSS, 4.9-12.4 % total sugars, 1.95-5.8 % reducing sugars, 2.2-8.4 % non reducing sugars and 66-133 mg/100 g ascorbic acid (Vitamin-C).

The jujube fruit is a small drupe, elliptic or oblong to spherical in form, from $\frac{1}{4}$ to 2 inches (1.27 cm to 5.08 cm) in length, with a thin dark brown skin, and having whitish flesh of crisp or mealy texture and sweet agreeable flavor noted by Popenoe (1974). He also stated that jujube fruits contained 0.29 per cent acids and 21.66 per cent total sugars. A comparative study with five Indian cultivars such as Gola, Kithli, Banarsi Karaka and Umran showed that Indian cultivar contained 81 to 97 per cent pulp, 2.7 to 12 per cent seed, 3.1-14.5 per cent total sugar, 1.4 to 9.7 per cent reducing sugar, 1.3 to 9.7 per cent non-reducing sugar, 0.13-1.42 per cent acidity and 39 to 166 mg ascorbic acid/100 g pulp. Cultivar Gola contained 95 per cent pulp, 4.7 per cent seed, and 8.3-12.1 per cent total sugar, 3.3 to 5.8 per cent reducing sugar, 2.4 to 8.4

per cent non-reducing sugar, 0.13 to 1.42 per cent acid and 70 mg ascorbic acid/100 g pulp. Cultivar Kaithli contained 96-97 per cent pulp, 3.5 per cent seed, 4.9 to 10 per cent total sugar, 1.95-2.7 per cent reducing sugar, 2.2 to 8.0 per cent non reducing sugar, 0.16-0.51 per cent acids and 89 to 133 mg ascorbic acid/100 g pulp. Banarsi Karaka fruit contained 96 to 97 per cent pulp, 3.9 per cent seed, 5.4 to 12.4 per cent total sugar, 3.3 to 3.7 per cent reducing sugar, 3.3 to 8.4 per cent non reducing sugar, 0.13 to 0.48 per cent acids and 66 to 110 mg vitamin-C/100 g pulp.

The Chinese jujube fruits have been reported to contain 20 to 28 per cent sugars, 0.3 to 2.5 per cent acids, 2.9 per cent protein, 500 to 600 mg/100 g pulp vitamin C and very high quantities of vitamin B complex (Trojan and Kruglyakov, 1972; Kuliev and Guseinova, 1974) while Baratov *et al.* (1975) reported 188 to 544 mg/100g pulp vitamin C and 9.65 to 32.6 per cent sugar.

In assessing some qualitative aspects of jujube fruits, it was observed that edible portion constituted 88 per cent of the total fruit weight. Regarding the sugar content, the fruit contained 10.24g of total sugar (per 100 g of edible portion), 4.36g and 5.98 g reducing and nonreducing sugar, respectively (Quadir and Hossain, 1995). He also stated that Malic acid was the major organic acid followed by malonic, fumaric, turmeric and citric acids. Total, free and combined acid contents were 118.86, 53.00 and 65.86 mg/100 g, respectively.

Mature fruits of the Indian jujube are very rich in nutritive substances. Its composition, however, varies in different cultivars. Also, differences in fruit composition occur in the cultivar from place to place and even at same location owing to changes in yearly climatic parameters and cultural practices followed. The major constituents of jujube fruit observed in different cultivars were 81 to 97 per cent pulp, 2.7 to 12 per cent seed, 12 to 21 per cent TSS (Brix), 3.1 to 14.5 per cent total sugar, to 9.7 per cent reducing sugar, 1.3 to 9.7 per cent non reducing sugar, 13 to 1.42 per cent acidity and 39-166 mg ascorbic acid per 100 g pulp (Randhawa and Biswas, 1966; Chandha *et al.*, 1972; Singh *et al.* 1973c; Teotia *et al.* 1974; Chundawat *et al.*, 1978).

Chapter III

I Materials and Methods

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The experiment was carried out at the Fruit Research Station, Binodpur, Rajshahi.

3.2 Experimental Period

The experiment was conducted during the period from August 2006 to March 2007.

3.3 Soil and climate

The soil texture of the experimental area was silt loam to clay with medium water holding capacity. The selected area was on a medium high land having pH value 6.5 and low organic matter content.

The locality where the experiment was conducted has a subtropical monsoon climate characterized by high temperature and heavy rainfall during the months of April to September and scanty rainfall during rest period of the year (October to March). During the study period the average monthly minimum and maximum temperature was 18.34°C and 29.43°C, respectively and the average relative humidity was 82.51 %. The total rainfall of the locality was 681 mm during the period from August 2006 to March 2007. The detailed meteorological data for the period of experiment are presented in appendix-2.

3.4 Materials

The experimental materials were mature fruits of 12 ber cultivars, namely Apple kul, BARI kul-1, BARI kul-2, Chapai kul, Dhaka-90 kill, Hazari kul, Khulna kul, Myanmar kul, Nabhi kul, off season kul, Sabji kul and Zahazi kul. Other

materials were used such as polythene bag, slide calipers, measuring scale, measuring tape, electrical balance, refractometer etc. The experiment was laid out in randomized complete block design with three replications. A single tree of each cultivar having uniform size and approximately same age constituted the unit of replication.

3.5 Methods

Data were collected by the researcher himself during the period from August 2006 to March 2007. During the period of data collection the researcher stayed at Fruit Research Station, Binodpur, Rajshahi.

3.6 Plant and yield parameters

3.6.1 Canopy of plant: Plant canopy spread (m) (east to west and north to south) was obtained by measuring tape from ground.

3.6.2 Date of flowering: In all the cultivars of ber studied flowering took place between August and September 2006.

3.6.3 Date of harvesting: Fruits of uniform maturity were harvested during the period from last January to march 2007.

3.6.4 Yield per plant: Yield per plant was recorded by weighing the fruits during harvesting.

3.6.5 Number of fruits per plant: Number of fruits per plant was recorded by counting the number of fruits during harvesting.

3.6.6 Yield per hectare:

Yield was calculated by multiplying the yield of individual plant with the number of plant per hectare (277 plants/ha). $\text{Yield (t/ha)} = \text{Yield of individual plant (in ton)} \times \text{number of plant per hectare}$.

3.7 Characteristics of the fruits

Three plants of similar age from each cultivar were selected for taking data. Uniformly matured 50 fruits from each tree were collected for taking data on characteristics of fruits.

3.7.1 Quantitative characters

Quantitative characteristics like weight, length, diameter and circumference of fruits; weight, length and diameter of seed; per cent edible portion and stone pulp ratio were studied in the laboratory.

- 3.7.1.1 Average weight of fruit:** Weight of ripe fruit of ber cultivars under study was found out by taking the mean of the weights (in gram) of 10 fruits from each plant with the help of an electrical balance.
- 3.7.1.2 Length of fruit (cm):** Length of fruit was recorded with the help of slide caliper. For this purpose 10 fruits were taken from each plant and length of each fruit was taken. Finally, the mean of the weight of fruits was found out.
- 3.7.1.3 Diameter of fruit (cm):** To find out the diameter of fruit, 10 fruits were taken from each of the 36 plants. Diameter (in cm) of each fruit was taken with the help of slide caliper and the mean diameter of 10 fruits was determined.
- 3.7.1.4 Circumference of fruit (cm):** Circumference of each fruit was taken with the help of measuring tape, then the mean circumference of 10 fruits from each of the 36 trees was computed.
- 3.7.1.5 Weight of seed (g):** Separation of the pulp from the seed was carefully done by hand. Weight of the seed of ber fruits was taken with the help of electrical balance.

3.7.1.6 Length and diameter of seed (cm): After separation from pulp, the seeds were washed with fresh water. The length and diameter of each seed were taken by the slide calipers (in cm) and then the mean value was calculated.

3.7.1.7 Per cent edible portion: The edible portion of the fruit was computed by the following formula:

$$\text{Edible portion (\%)} = \frac{\text{Weight of fruit} - \text{weight of seed}}{\text{Weight of fruit}} \times 100$$

3.7.1.8 TSS value (%): TSS value of each cultivar determined with the help of hand refractometer.

3.7.1.9 Per cent stone/seed: Percent stone was calculated by deducting percent edible portion from 100.

3.7.1.10 Seed pulp ratio: It was obtained by dividing seed weight with the pulp weight

i.
$$\frac{\text{Seed weight}}{\text{Pulp weight}} \text{ e., seed pulp ratio=}$$

3.7.2 Qualitative characters

Qualitative characteristics include fruit shape, seed shape, styler end and stem end of fruit, fruit surface, skin thickness, skin color, flesh color, attractiveness etc.

3.7.2.1 Skin thickness: Skin thickness was determined by peeling out the skin from pulp.

3.7.2.2 Fruit surface: Nature of fruit surface was found out through finger touch. Other characteristics such as fruit and seed shape, styler end and stem end of fruit, skin color, flesh color and attractiveness were determined through eye estimation.

3.8 Organoleptic test of fruits

Organoleptic test in respect of fruit texture, juiciness, sweetness and market demand of the fresh fruits were done by panel of 25 judges of 20-40 years age group. The panel members were the staff of Fruit Research Station, Binodpur, Rajshahi. For doing this fresh fruit were placed in white plastic plate and served to the members of the test panel. The panelist recorded their preferential comments in the supplied questionnaire (Appendix 3). The results were presented both in percentage and acceptability score figures. Acceptability scores were compiled according to a scale suggested by Hossain and Siddique (1982). The scale provided scores of a, b and c for preferential comments highly acceptable, slightly acceptable and unacceptable, respectively.

3.9 Statistical Analysis

The data recorded in the experiment for different characters were analysed statistically to find out the significance of treatments effect. Analysis of variance was done by the 'F' (Variance ratio) test and treatment means were separated by Duncan's New Multiple Range Test (DMRT) for interpretation of results (Steel and Torrie, 1960).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results obtained from the study have been described and discussed character wise under separate heading in this chapter. A summary of the analysis of variance in respect of all the characters studied together with their source of variation and their corresponding degrees of freedom have been shown in appendix-1.

4.1. Plant spreading, flowering and harvesting time of fruits

Plant spreading

The east-west spreading of ber plants varied from 5.83 m to 6.83 m (Table 1). Zahazi kul plants spreaded widely (6.83 m) which was significantly superior over other cultivars. The spreading (east-west) of Hazari kul plants (5.83 m) and Myanmar kul plants (5.83 m) were statistically identical but differed from those of the rest cultivars. The north-south spreading of ber plants were also influenced by cultivars (Table 1). Widest spreading (6.7 m) was recorded in Nabhi kul plants followed by Sabji kul plants (6.17 m). The spreading (north-south) of all the cultivars were statistically similar (Table 1).

Flowering time

In all the cultivars of ber studied flowering took place between the month of August and September (Table 1). The early flowering cultivars were Apple kul, BARI kul-1, BARI kul-2, Chapai kul, Hazari kul, Khulna kul, Myanmar kul, Sabji kul and Zahazi kul. Dhaka-90 kul, Nabhi kul and Off season kul were the late flowering cultivars *i.e.* flowering took place in the month of September.

Harvesting time

Among the ber cultivars studied Sabji kul, Apple kul, BARI kul-1, BARI kul-2, Chapai kul, Hazari kul, Khulna kul and Myanmar kul were the early cultivars where fruits were harvested in February (Table 1). The late harvesting cultivars were Dhaka-90 kul, Nabhi kul, Off season kul and Zahazi kul. Fruits of those cultivars attained their full maturity by the 1st fortnight of March. Early cultivars are always preferred due to high demand and higher market price.

Table 1. Plant spreading, flowering and harvesting time of fruits in twelve cultivars of ber

Cultivar	Plant spreading (m)		Flowering time	Harvesting time
	East-west	North-south		
Apple kul	6.67a	5.83a	August	February
BARI kul-1	6.33ab	6.07a	August	February
BARI kul-2	6.65a	5.90a	August	February
Chapai kul	6.15ab	5.83a	August	February
Dhaka- 90 kul	6.15ab	5.67a	September	March
Hazari kul	5.83b	5.90a	August	February
Khulna kul	6.23ab	5.67a	August	February
Myanmar kul	5.83b	5.67a	August	February
Nabhi kul	6.23ab	6.70a	September	March
Off season kul	6.27ab	5.83a	September	March
Sabji kul	6.33ab	6.17a	August	February
Zahazi kul	6.83a	6.00a	August	March
CV(%)	4.46	7.94		

Average fruit weight

The twelve cultivars of ber had significant influence in respect of average fruit weight (Table 2). The average fruit weight varied from 45.17g to 13.00g. In respect of variety, Dhaka-90 kul. produced the heaviest fruits (45.17g) followed by Mayanmer kul (35.83g) which was statistically significant. Smallest fruit (13.00g) was observed in Apple kul which was statistically similar to that of Chapai Kul. Most of the cultivars produced the fruits of similar weight such as BARI kul-1 (21.67g), BARI kul-2 (24.00g), Khulna kul (24.17g), Nabhi kul (25.00g), Sabji kul (22.67g) and Zahazi kul (22.67g). The results indicated that the average fruit weight varied from cultivar to cultivar. The present results except Dhaka-90 kul and Myanmar kul was close to the findings of Quadir and Hossain (1995) where ber fruits weight was 15.40g.

Length of fruit

Significant variation was observed in fruit length of ber due to cultivars (Table 2). Maximum fruit length (5.08 cm) was recorded in Dhaka-90 kul which was statistically similar to that of BARI kul-1 (4.93 cm) and Nabhi kul (4.95 cm). The shortest one was the Apple kul (3.20 cm) which was statistically similar with the cultivars of BARI kul-2 (3.21 cm), Hazari kul (3.21 cm), Khulna kul (3.28 cm), Chapai kul (3.33 cm) and Off season kul (3.38 cm). Myanmar kul (4.18 cm), Sabji kul (4.00 cm) and Zahazi kul (3.88 cm) showed intermediate in length. The results indicated that fruit length was varied mainly by the inherent nature of the cultivars concerned. The results of the experiment support the findings of Bal *et al.*, (1988) who reported that the length of 'Umran' fruit was 4.36 cm.

Diameter of fruit

Diameter of fruit showed a wide variation within the cultivars (Table 2). Dhaka-90 kul exhibited the highest fruit diameter (3.98 cm) and was statistically superior to all other cultivars. BARI kul-2 also showed the larger diameter (3.63 cm). Apple kul produced the fruits having the shortest diameter (2.68 cm) which was statistically similar to Chapai kul (2.70 cm). The other cultivars showed the intermediate diameter ranged from 2.78cm to 3.21 cm. The present findings were very close to the findings of Bal *et al.*, (1998) who mentioned that the diameter of Umran jujube was 3.15 cm.

Circumference of fruit

Significant variation for circumference of fruit was noticed among the cultivars (Table 2). The circumference of fruits ranged from 8.66cm to 12.53 cm. Maximum circumference of fruit (12.53 cm) was recorded in Dhaka-90 kul due to heaving average size of fruits which was superior to other cultivars. Minimum circumference of fruit (8.66 cm) was observed in Apple kul. Circumference of fruits of rest of the cultivars ranged from 9.00cm to 10.53 cm.

Cultivar	Average fruit weight (g)	Length of fruit (cm)	Diameter of fruit (cm)	Circumference of fruit (cm)
Apple kul	13.00 g	3.20 c	2.68 g	8.66 g
BARI kul-1	21.67 d	4.93 a	3.27 c	10.40 be
BARI kul-2	24.00 c	3.21 c	3.63 b	10.47 be
Chapai kul	14.00 g	3.33 c	2.70 g	9.00 f
Dhaka-90 kul	45.17 a	5.08 a	3.98 a	12.53 a
Hazari kul	15.33 f	3.21 c	2.78 f	9.33 e
Khulna kul	24.17 c	3.28 c	3.28 c	10.57 b
Myanmar kul	35.83 b	4.18 b	3.27 c	10.53 be
Nabhi kul	25.00 c	4.95 a	3.18 de	10.23 c
Off season kul	18.00 e	3.38 c	3.23 cd	9.83 d
Sabji kul	22.67 d	4.00 b	3.15 f	10.38 be
Zahazi kul	22.67 d	3.88 b	3.21 cde	10.47 be
CV(%)	2.82	0.86	1.22	1.88

Note: Values having uncommon letter (s) differs significantly at 1 % level of significance

Average seed weight (g)

Among the cultivars of ber, the seeds of Dhaka-90 kul were the heaviest in weight (3.45g) and those of Apple kul were the lightest (0.90 g) (Table 3). The seeds of BARI kul-1, BARI kul-2, Chapai kul, Nabhi kul, Hazari kul, Khulna kul, Myanmar kul and Off season kul were rather lighter in weight having the mean seed weight ranged from 0.98 to 1.40 g. The seeds of Chapai kul, Off season kul and Hazari kul, Nabhi kul were similar in weight having the average seed weight of 1.0 g and 1.1 g respectively. On the other hand, seeds of Sabji kul and Zahazi kul were medium in weight having the mean weight of 2.47 g and 2.00 g respectively. According to Bal *et al* (1988) jujube fruit contained seed having 1.54 g in weight. The present findings were lower than the reports of Bal *et al* (1988) except Dhaka-90 kul, Sabji kul and Zahazi kul. The variation might be due to the differences in the cultivars or ecological variation or both.

Length of seed

Variations in length of seed were observed in seed of different cultivars of ber (Table 3). The longest seed was found in Dhaka-90 kul (3.10 cm) and the shortest 1.68cm were observed in Apple kul followed by other cultivars. The seed length of BARI kul-1, BARI kul-2, Khulna kul, Myanmar kul, Nabhi kul, Off season kul, Sabji kul, Zahazi kul were medium in length which ranged from 2.00 to 2.68 cm. The results were in agreement with the findings of Quadir and Hossain (1995) who noted that the jujube fruits contained 1.96 cm long seed.

Diameter of seed

The diameters of seeds of different cultivars were statistically differed (Table 3). The highest diameter was found in Dhaka-90 kul (1.30 cm) and smallest seed diameter was found in Apple kul which was statistically similar to that of BARI kul-2, Chapai kul, Hazari kul, Khulna kul, Myanmar kul, Nabi kul and Off season kul. The results strongly support the findings of Quadir and

Hossain (1995) who stated that the average diameter of seed in jujube was 0.83 cm. Considering weight and size of seeds Apple kul was superior and Dhaka-90 kul was inferior to others.

4.4 Seed-pulp ratio

The seed pulp ratio of twelve ber cultivars ranged from 1 : 8.18 to 1 : 32.18 (Table 3). The ratio of seed-pulp was the highest (1 : 32.18) in the fruits of Myanmar kul whereas it was lowest (1 : 8.18) in fruits of Sabji kul. Seed-pulp ratio of Apple kul, Chapai kul, Dhaka-90 kul, Hazari kul were 1 : 13.44, 1 : 13, 1 : 12.96, 1 : 12.93 respectively which were more or less similar. On the other hand, BARI kul-2 showed the better seed-pulp ratio (1 : 23.48).

Table 3. Quantitative characteristics of seeds in twelve cultivar of ber

Cultivar	Average seed weight (g)	Length of seed (cm)	Diameter of seed (cm)	Seed-pulp ratio
Apple kul	0.90 h	1.68 h	0.93 d	1 : 13.44
BARI kul-1	1.16 e	2.10 e	1.20 b	1 : 17.68
BARI kul-2	0.98 gh	2.11 e	1.00 d	1 : 23.48
Chapai kul	1.00 fg	1.91 fg	0.94 d	1 : 13
Dhaka-90 kul	3.45 a	3.10 a	1.30 a	1 : 12.96
Hazari kul	1.10 e	1.88 g	0.99 d	1 : 12.93
Khulna kul	1.40 d	2.00 f	0.97 d	1 : 16.26
Myanmar kul	1.08 ef	2.68 b	0.98 d	1 : 32.18
Nabhi kul	1.10 e	2.60 b	0.94 d	1 : 21.73
Off season kul	1.00 fg	2.30 cd	0.97 d	1 : 17
Sabji kul	2.4 b	2.31 c	1.10 c	1 : 8.18
Zahazi kul	2.00 c	2.21 d	1.10c	1 : 10.34
CV(%)	3.88	2.51	4.78	

Note: Values having uncommon letter (s) differs significantly at 1% level of significance

4.5 Total soluble solids (TSS)

Significant influences on the total soluble solids (TSS) content of fruits were observed among the cultivars (Table 4). The fruits of Apple kul were found to be superior among the ber cultivars and recorded the highest total soluble solids (15.00 %). The lowest TSS content was observed in the fruits of Myanmar kul (12.00 %). The TSS content (14.00 %) of BARI kul-1, Nabhi kul, Khulna kul, Dhaka-90 kul and Sabji kul were statistically similar. The rest of the cultivars showed TSS value %. The results are in agreement with the findings of Singh *et al.*, (1983) who recorded TSS value 13.61 % in ber.

4.6 Shelf life

Shelf life of twelve ber cultivars was ranged from 3 to 5 days at room temperature (Table 4). The highest shelf life was observed in Apple kul (5 days) and the lowest in Chapai kul (3 days). The shelf life of rest of the cultivars was same (4 days).

Table 4. Total soluble solids and shelf life of fruits in twelve cultivars of ber

Cultivar	TSS (%)	Shelf life (Day)
Apple kul	15.0 a	5
BARI kul-1	14.0 ab	4
BARI kul-2	13.0 be	4
Chapai kul	13.0 be	3
Dhaka-90 kul	14.0 ab	4
Hazari kul	13.0 be	4
Khulna kul	14.0 ab	4
Myanmar kul	12.0 c	4
Nabhi kul	14.0 ab	4
Off season kul	13.0 be	4
Sabji kul	14.0 ab	4
Zahazi kul	13.0 be	4
CV(%)	7.63	

Note: Values having uncommon letter (s) differs significantly at 1 % level of significance

4.7 Per cent edible portion

It was observed from the study that there was a significant variation among the ber cultivars in percentage of pulp content (Fig. 1). The recorded data showed that the cultivar of Myanmar kul contained the highest amount of pulp (96.98 %) which was statistically followed by BARI kul-2 (95.91 %) and Nabhi kul (95.6 %). The lowest amount of pulp was recorded in Sabji kul (89.10 %). The present findings were similar with the findings of other scientists like Randhawa and Biswas (1966); Chandha *et al.*(1972); Singh *et al.*(1973c); Dhingra *et al.*(1973); Teotia *et al.*(1974) and Chundawat *et al.* (1978). The results indicated that Myanmar kul was superior and Sabji kul was inferior to other cultivars in respect of per cent edible portion.

4.8 Per cent seed

Significant variations were recorded among the cultivars of ber in respect of percentage of seed (Fig. 1). It varied from 3.02% to 10.9 %. The highest percentage of seeds was observed in Sabji kul (10.9) which was significantly higher than the rest. The lowest percentage of seed was in the cultivar of Myanmar kul (3.02). It indicated that Myanmar kul was superior to others. Pareek (1983a) reported that Indian cultivar of jujube contained 2.7 to 12 percent seed. The results of the present study were within the range of report.

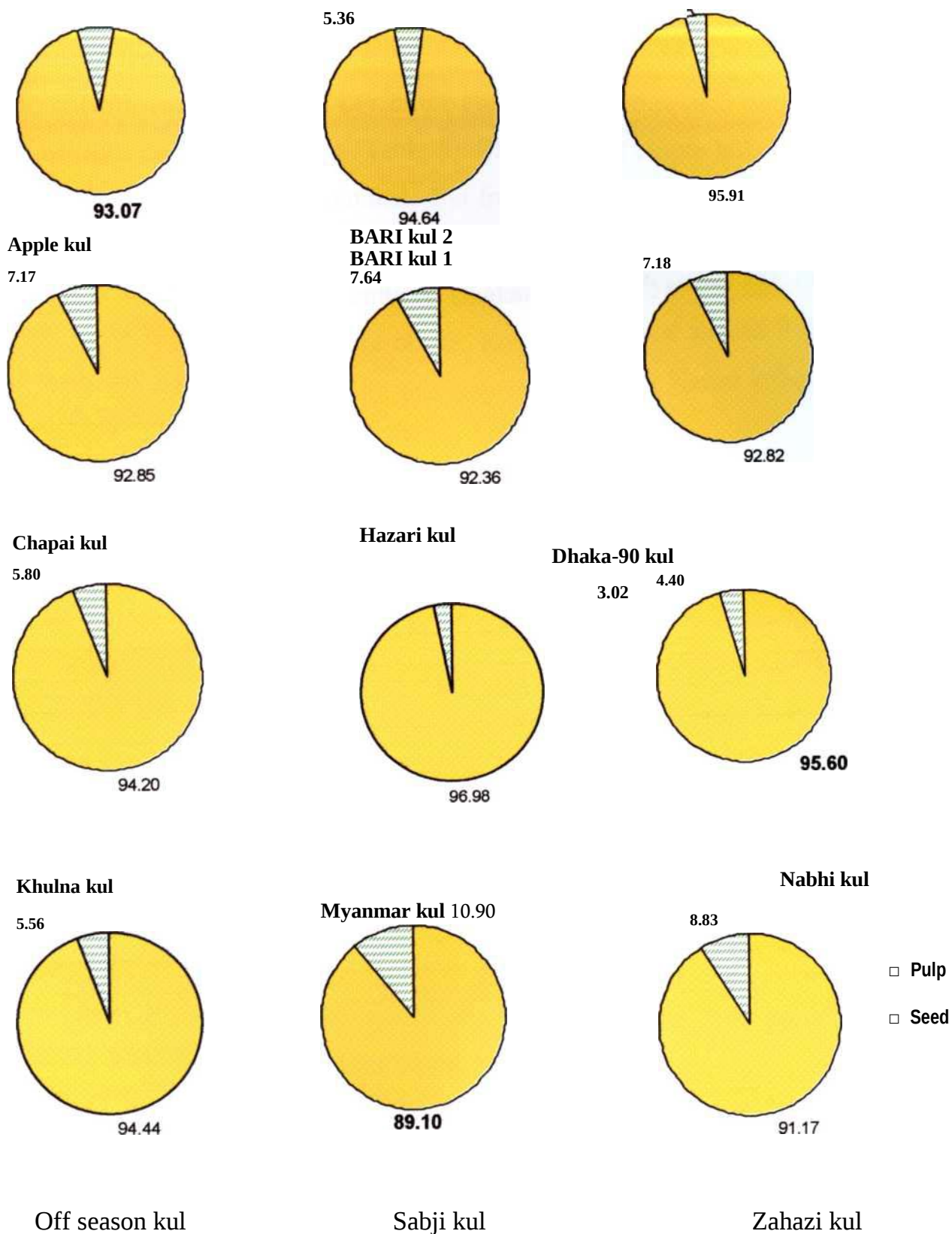


Fig 1. Percentage of pulp and seed of different ber cultivars

4.9 Quantitative characteristics of fruits

Shape of fruit

Different cultivars of ber differ significantly from each other in expressing the shape of fruit (Table 5). The fruits of Apple kul, BARI kul-2 and Hazari kul were roundish. But fruits of Chapai kul, Khulna kul and Sabji kul were oval. Oblong shaped fruits were found in BARI kul-1 and Nabhi kul, whereas the fruits of Dhaka-90 kul, Myanmar kul, Off season kul and Zahazi kul were oblate. Roundish or oval shaped fruits looked very nice or attractive. In this respect Apple kul, Hazari kul and BARI kul-2 were very attractive.

Styler end

Styler end of fruits of ber varied from round to pointed. Round styler end was observed in BARI kul-2, Chapai kul and Hazari kul (Table 5). On the other hand, the fruits of Apple kul, Khulna kul, Sabji kul, Off sason kul and Zahazi kul were roundish. Pointed and slightly pointed shaped fruits were found in BARI kul-1, Myanmar kul and Nabhi kul. Among the cultivars only Dhaka-90 kul showed the slightly tapering shaped kul. According to Pareek (1983), the styler end of fruits of cultivar 'Ilaichi' was round, 'Delhi gola' was roundish, 'Badshah pasand' and 'Banarasi' were slightly tapering, 'Choara chhuhara' was slightly depressed and 'Banarasi pewandi' was slightly pointed. The present studies are in agreement with the report.

Stem end

Stem end of fruit also differed from cultivar to cultivar (Table 5). The fruits of Apple kul, BARI kul-1, Hazari kul, Khulna kul, Sabji kul, Off season kul and Zahazi kul were slightly depressed to depressed stem end. BARI kul-2, Chapai kul, Dhaka-90 kul and Nabhi kul showed round stem end. On the other hand, the stem end of fruits of Myanmar kul was roundish.

The results support the findings of Pareek (1983) who reported that the stem end of cultivar ‘Choara chhuhara’ and ‘Chonchal’ were round; Ilaichi was flattened; ‘Bekata varanasi’ was depressed; ‘Glory’ was tapering; ‘Deshi Alwar’ was ridged and ‘Badshah pasand’ was obtuse.

Skin thickness

The fruits of the cultivar Dhaka-90 kul, Myanmar kul and Off season kul were thick while the fruits of Apple kul, BARI kul-1, BARI kul-2, Chapai kul, Hazari kul, Khulna kul, Nabhi kul and Sabji kul were thin in respect of skin thickness. Skin colour

Variation in colour of skin was observed in fruits of different cultivars of ber (Table 5). The skin colour of fruits of Chapai kul, Dhaka- 90 kul, Khulna kul, Off season kul and Zahazi kul was greenish yellow. Light greenish yellow skin colour was observed in the cultivars of BARI kul-1, BARI kul-2, Myanmar kul and Sabji kul. Dark greenish yellow skin colour was observed in Nabhi kul. Upper part apple colour, lower part light yellow and upper part reddish, lower part light green skin colour were found in Apple kul and Hazari kul respectively. Usually apple and yellow coloured fruits are very nice to look at. Considering this parameter Apple kul was superior due to its apple colour.

Fruit surface

The fruit surface of all the cultivars was smooth except the fruits of BARI kul-2, Sabji kul and Zahazi kul which were smooth and shiny (Table 5). Pareek (1938) stated that the fruit surface of Badami and Badshah Pasand ber were smooth, ‘Glory’ kul was smooth and shiny but in case of cultivar ‘Banarasi’ few scattered brownish strips were found on the fruit surface.

Flesh colour

Cream and white flesh colours were found in fruits among the cultivars. Cream flesh colour was observed in Apple kul, Chapai kul, Dhaka-90 kul, Hazari kul and Khulna kul (Table 5). On the other hand, BARI kul-1, BARI kul-2, Myanmar kul, Nabhi kul, Off season kul, Sabji kul and Zahazi kul showed white flesh colour.

Attractiveness of fruits

Attractiveness is one of the best attributes to the consumers. In this respect fruits of different cultivars were ranged from attractive to very attractive. Very attractive fruits were found in the cultivars of Apple kul, BARI kul-2 and Hazari kul. The rest of the 9 cultivars i. e., BARI kul-1, Chapai kul, Dhaka-90 kul, Khulna kul, Myanmar kul, Nabhi kul, Off season kul, Sabji kul and Zahazi kul produced fruits having attractive appearance



Table 5. Qualitative characteristics of fruits in twelve cultivars of ber

Cultivar	Fruit shape	Styler end	Stem end	Skin thickness	Skin colour	Fruit surface	Flesh colour	Attractiveness
Apple kul	Roundish	Roundish	Slightly depressd	Thin	Upper part apple colour and lower part light colour	Smooth	Cream	Very attractive
BARI kul- 1	Oblong	Slightly pointed	Slightly depressed	Thin	Light greenish yellow	Smooth	White	Attractive
BARI kul- 2	Roundish	Round	Round	Thin	Light greenish yellow	Smooth and shinny	White	Very attractive
Chapi kul	Oval	Round	Round	Thin	Greenish yellow	Smooth	Cream	Attractive
Dhaka-90 kul	Oblate	Slightly tapering	Round	Thick	Greenish yellow	Smooth	Cream	Attractive
Hazari kul	Roundish	Round	Slightly-depressed	Thin	Upper part reddish and lower part light green	Smooth	Cream	Very attractive
Khulna kul	Oval	Roundish	Slightly depressed	Thin	Greenish yellow	Smooth	Cream	Attractive
Myanmar kul	Oblate	Pointed	Roundish	Thick	Light greenish yellow	Smooth	White	Attractive
Nabhi kul	Oblong	Pointed	Round	Thin	Dark greenish yellow	Smooth	White	Attractive
Off season kul	Oblate	Roundish	Depressed	Thick	Greenish yellow	Smooth	White	Attractive
Sabji kul	Oval	Roundish	Slightly depressed	Thin	Light greenish yellow	Smooth & shinny	White	Attractive
Zahazi kul	Oblate	Roundish	Depressed	Thin	Greenish yellow	Smooth & shinny	White	Attractive



Apple kul



BARI kul-1



BARI kul-2



Chapi kul

Fig. 2 Showing fruits and seeds of different ber cultivars.



Dhaka-90 kul



Hazari kul



Khulna kul



Myanmar kul

Fig. 3 Showing fruits and seeds of different ber cultivars.



Subjekt



2000

2000

Zahazi kul

nt ber cultivars.

Number of fruits per plant was significantly influenced by ber cultivars (Fig. 5). The highest number of fruits per plant was recorded in Apple kul (3776) followed by Chapai kul (3223) and BARI kul-2 (3065). Dhaka-90 kul produced only 1938 fruits per plant and was significantly lower than other cultivars. The highest number of fruits per plant in Apple kul might be closely associated with their small size of fruits. On the other hand, the lowest number of fruits per plant in Dhaka-90 kul also might be closely related with their largest size of fruits. The average number of fruits per plant ranged from 1938 to 3776 among the ber cultivars studied.

Yield per plant

Significant variation in fruit yield per plant was noticed among the cultivars of ber (Fig. 6). Dhaka-90 kul yielded highest (87.57 kg) followed by the cultivar BARI kul-2 (74.0 kg) and Myanmar kul (72.0 kg). The highest yield of Dhaka-90 kul was due to largest size of fruits. Per plant yield of Off season kul (46.0kg) and Sabji kul (46.0 kg) was statistically similar. The lowest per plant yield was obtained from the cultivar of Hazari kul (44.9 kg) which was statistically similar to Chapai kul (45.0 kg).

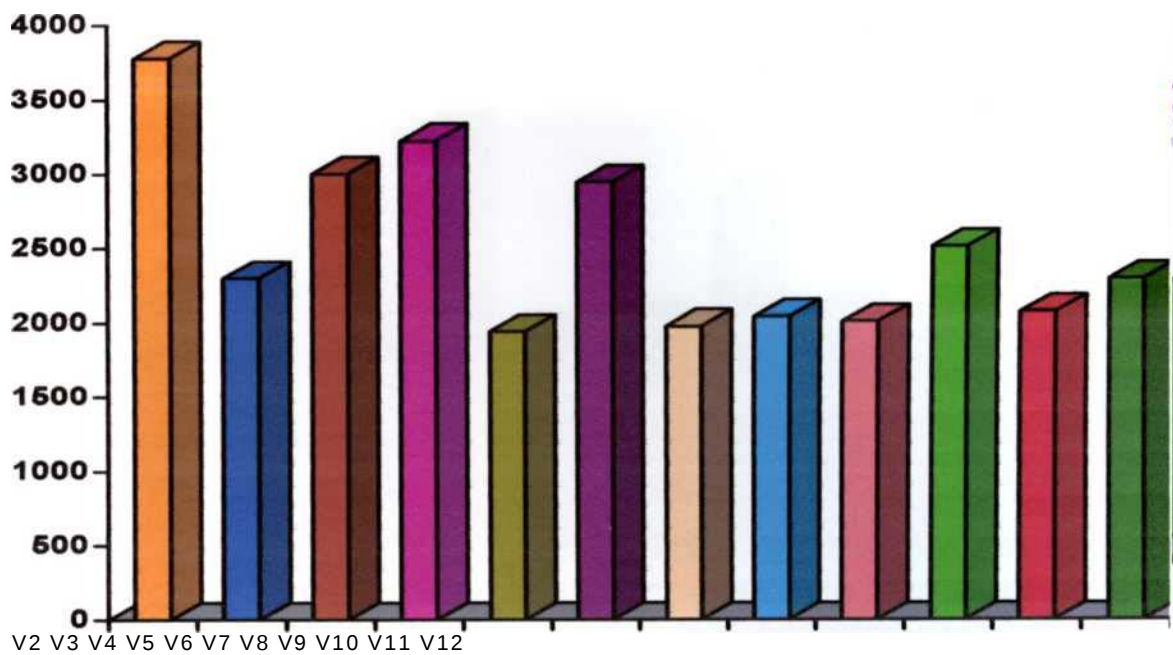
Yield per hectare

The per plant yield was converted into per hectare yield. Dhaka-90 kul (24.25 t) produced the highest yield followed by BARI kul-2 (20.38 t) and Myanmar kul (20.24 t) (Fig. 7). The lowest yield was obtained from the cultivar of Off season kul (12.50 t), Hazari kul (12.5 t) and Chapai kul (12.5 t). The rest of the cultivars produced intermediate yield which ranged from to 14.38 t/ha.

Fig 5. Number of fruits per plant of different ber cultivars

Note:

VI =Apple kul, V2=	V7= Khulna kul,
BARI kul- 1, V3=	V8= Myanmar kul,
BARI kul-2, V4=	V9= Nabhi kul,
Chapai kul, V5=	V10= Off season kul,
Dhaka-90 kul, V6=	VI1= Sabji kul,
Hazari kul,	VI2 Zahazi kul



Different ber cultivars

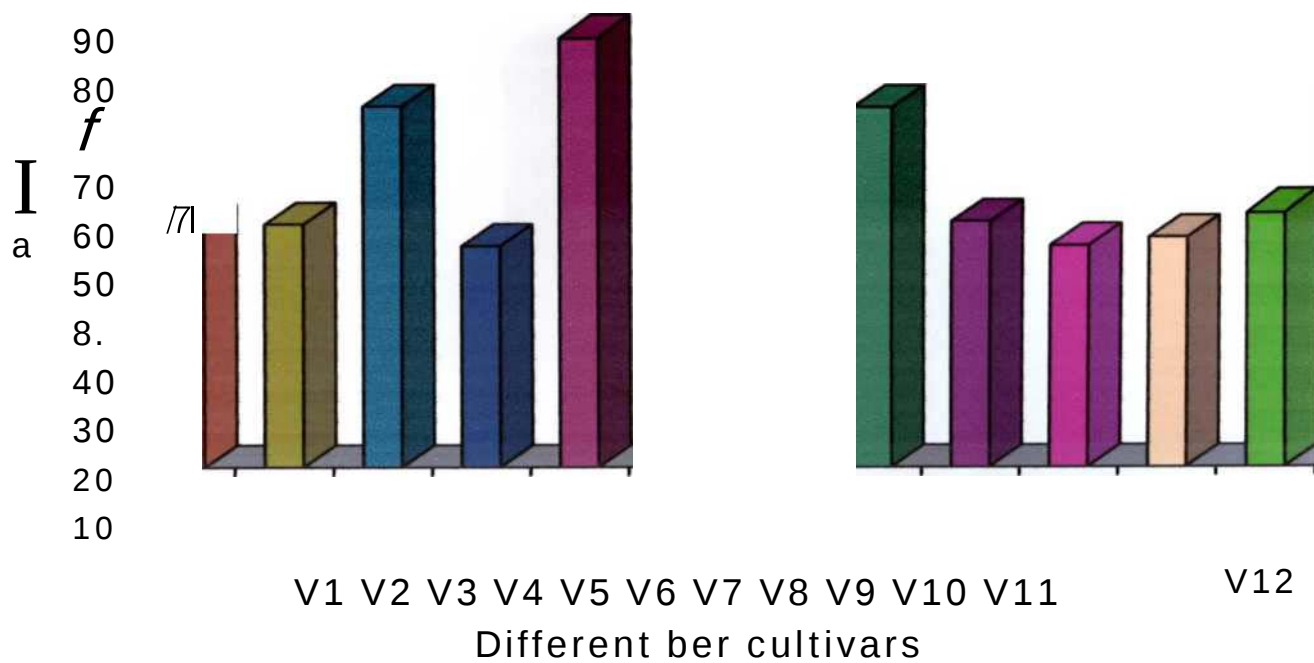


Fig 6. Yield per plant of different ber cultivars

Note:

V1 =Apple kul,

V2= BARI kul- 1,

V3= BARI kul-2,

V4= Chapai kul,

V5= Dhaka-90 kul,

V6= Hazari ku

V7= Khulna kul,

V8= Myanmar kul,

V9= Nabhi kul,

V10= Off season kul,

VI1= Sabji kul,

VI2= Zahazi kul

Different ber cultivars

Fig 7. Yield of different ber cultivars

Note:

VI =Apple kul,

V2= BARI kul- 1,

V3= BARI kul-2,

V4= Chapai kul,

V5= Dhaka-90 kul,

V6= Hazari kul,

V7= Khulna kul,

V8- Myanmar kul,

V9= Nabhi kul,

V10= Off season

kul, VI1= Sabji

kul,

VI2= Zahazi kul

4.11 Organoleptic test of fruits

Consumers acceptability of ber depend mainly on appearance and sweetness. Hence organoleptic test were done on texture , juiciness, sweetness and market demand. Rahman (1999) also conducted same type of experiment in jujube fruits taking the parameters of skin colours, shape, flavor, taste, texture and sweetness.

The result of the preferential comments from the panelist are summerised in table 6 and 7. When preferential comments were converted into acceptability scores the cultivars Apple kul, BARI kul-1, BARI kul-2, Chapai kul and Hazari kul got the top score on the basis of total acceptability ranking (Table-6) and the score were more than 487. The lowest score was recorded in Zahazi kul (434).

Fruit texture is one of the important parameters in selection of cultivar. In this study, the cultivar BARI kul-1, Apple kul and chapi kul topped the list of first three. The fruits of Apple kul and BARI kul-1 were firm textured.

In case of juiciness BARI kul-1, Apple kul, Chapai kul, BARI kul-2 and Myanmar kul scored the best. The fruits of BARI kul-1 and Apple kul were very juicy.

Considering the sweetness of fruits Apple kul, BARI kul-1, BARI kul-2 and Chapai kul had higher score (Table 7).

The best accepted cultivar in respect of market demand was Apple kul which scored 165 and the lowest score was observed in cultivar Dhaka-90 kul (99). Apple kul scored the highest in total acceptability score, but it scored second in case of juiciness and equal to BARI kul-1 in respect of fruit texture

Table 6. Organoleptic test of fruits in twelve ber cultivars

Cultivar	% Tester											
	Fruit texture			Juiciness			Sweetness			Market demand		
	HA	SA	UA	HA	SA	UA	HA	SA	UA	HA	SA	UA
Apple kul	52	37	11	47	44	09	51	40	09	85	15	00
BARI kul-1	62	22	16	60	29	11	53	31	16	28	63	09
BARI kul-2	39	40	20	44	39	17	52	37	11	23	62	15
Chapai kul	38	50	12	33	55	12	33	58	09	18	64	18
Dhaka-90 kul	34	49	17	30	44	26	26	37	37	00	61	39
Hazari kul	35	45	20	46	54	10	28	60	12	12	76	12
Khulna kul	18	64	18	20	47	33	31	43	26	06	72	22
Myanmar kul	23	62	15	28	60	12	31	43	26	12	73	15
Nabhi kul	19	54	27	24	52	24	25	49	26	27	69	04
Off seasonkul	23	62	15	24	59	17	24	56	20	07	65	28
Sabji kul	23	62	15	24	56	20	24	52	24	13	66	21
Zahazi kul	20	47	33	25	49	26	20	47	33	00	75	25

HA= Highly Acceptable SA= Slightly Acceptable UA= Unacceptable

Table 7. Acceptability scores in twelve ber cultivars

Cultivar	Acceptability scores					
	Fruit texture	Juiciness	Sweetness	Market demand	Total	Remarks
Apple kill	135	135	137	165	572	1 st
BARI kul-1	135	139	131	127	532	2 nd
BARI kul-2	123	127	135	121	506	3 rd
1 Chapai kul	129	127	129	117	502	4 ^m
1 Dhaka-90 kul	123	115	107	99	444	
1 j Hazari kul	121	123	125	119	488	5 ^m
1 Khulna kul	117	107	115	111	450	
1 Myanmar kul	121	125	115	117	478	
1 Nabhi kul	111	115	113	131	470	
1 Off seasonkul	121	119	117	107	464	
II Sabji kul	121	117	115	113	466	
Zahazi kul	107	113	107	107	434	

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Fruit Research Station, Binodpur, Rajshahi during the period from August 2006 to March 2007 to study on yield and quality of fruits of different ber cultivars. The treatment of the experiment consisted of twelve ber cultivars viz. Apple kul, BARI kul-1, BARI Kul-2, Chapai kul, Dhaka-90 kul, Hazari kul, Khulna kul, Myanmar kul, Nabhi kul, Off season kul, Sabji kul and Zahazi kul. The experiment was set on existing plantation of Fruit Research Station, Rajshahi. The experiment was laid out in Randomized Complete Block Design with three replications.

Observations were recorded on plant spread, flowering and harvesting period, fruit per plant, yield per plant, fruit shape, skin colour, flesh colour, attractiveness, skin thickness, fruit size, fruit weight, seed size, total soluble solid. Twenty fruits were randomly taken from each plant for collecting the data for fruit characteristics. Yield per plant were recorded from the total weight of harvested fruits. The per plant yield was converted into per hectare yield. The East- west and North- south spreading off plants ranged from 5.83m to 6.83m and 5.67m to 6.7m respectively. In all the cultivars of ber studied flowering took place between the month of August and September. Fruits of uniform maturity were harvested during the period from January to March.

The fruit weight, length, diameter and circumference ranged from 13.0 to 45.17 g, 3.20 to 5.08 cm, 2.68 to 3.94 cm and 8.66 to 12.53 cm, respectively. The highest average weight, length, diameter and circumference of fruit were observed in Dhaka -90 kul and lowest in Apple kul.

Average seed weight was lowest in Apple kul (0.90) and highest in Dhaka- 90 kul (3.45g). Length of seed ranged from 1.68 cm to 3.10 cm where Apple kul was lowest and Dhaka-90 kul was highest.

Diameter of seed also highest in Dhaka-90 kul and lowest in Apple kul. Myanmar kul produced the maximum seed- pulp ratio (1:32.18) and Sabji kul produced the minimum (1:8.18).

Per cent edible portion and per cent seed ranged from 89.10 to 96.98 and 3.02 to 10.9, respectively. The maximum edible portion and percent seed were found in the variety of Myanmar kul and Sabji kul respectively. The minimum per cent seed was observed in Myanmar kul and minimum edible portion was found in Sabji kul. Only the variety Apple kul produced the fruits having the highest TSS (15.00 %) and the variety Myanmar kul produced the fruits of lowest TSS (12.0%).

The fruits of cultivars Apple kul, BARI kul-2 and Hazari kul were roundish in shape whereas Chapai kul, Khulna kul and Sabji kul were oval. Oblate shaped fruits were found in Dhaka-90 kul, Myanmar kul, Off season kul and Zahazi kul. The fruits of BARI kul-1 and Nabhi kul were oblong. Roundish styler end was observed in the fruits of Apple kul, Khulna kul, Off season kul and Sabji kul. Fruits having round styler end were observed in BARI kul-2, Chapai kul and Hazari kul. Slightly depressed stem end was found in the fruits of Apple kul, BARI kul -1, Hazari kul, Khulna kul and Sabji kul.

The mature fruits of all the cultivars were greenish yellow to light greenish yellow except the fruits of Apple kul and Hazari kul which were apple colour at the upper part and light green colour at the lower part. Fruits surface of most of the cultivars were smooth but Sabji kul, BARI kul-2 and

Zahazi kul had smooth and shiny surface. Flesh colour of fruits among the cultivars varied from cream to white. Apple kul, Chapai kul, Dhaka -90 kul, Hazari kul and Khulna kul had cream flesh colour and rest of the cultivars had white colour. The fruits of Apple kul, BARI kul - 2 and Hazari kul were very attractive.

Apple kul produced the maximum number of fruits per plant (3776) while the lowest number of fruit per plant (1938) was noted in Dhaka-90 kul. But Dhaka -90 kul produced highest yield per plant (87.57 kg) while Apple kul produced intermediate yield (49.08 kg) inspite of its higher number of fruits per plant. Finally the yield per hectare was highest in Dhaka-90 kul (24.25 t) and lowest in Chapai kul (12.5 t), Hazari kul (12.50 t) and Off season kul (12.50 t). Apple kul produced the intermediate yield (13.6 t/ha) which was statistically similar to BARI kul- 1, Khulna kul, Nabhi kul and Sabji kul. The market price of Apple kul was also highest.

Considering the performance in respect of fruit characters, earliness, attractiveness and market demand, it may be concluded that the cultivar Apple kul was found superior to all other cultivars under study.

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Appendices

Appendix 1: Analysis of variance of the data on characteristics of plant, fruit, seed and yield components of ber as influenced by cultivars/varieties—

Source of variation	Degrees of freedom	Mean sum of squares					
		Plant spreading (North-South)	Plant spreading (East-West)	Average weight of fruit	Length	Diameter	Circumference
Replication	2	0.032	0.072	0.271	0.000	0.000	0.013
Variety	11	0.097	0.283**	252.729**	1.653**	0.413**	2.887**
Error	22	0.219	0.079	0.437	0.001	0.002	0.035
Non	1	0.232	0.004	0.847	0.000	0.000	0.038
additivity	21	0.218	0.082	0.418	0.001	0.002	0.035

Residual

Degrees of freedom	Mean sum of squares				
	Average seed weight	Length of seed	Diameter of seed	TSS	Fruits per plant

Total 35

Table 1: Continued

Replication	2	0.001	0.001	0.001	0.333	4221.694	1.287
Variety	11	1.836**	0.466**	0.040	1.909**	1067506.391**	609.405**
Error	22	0.003	0.003	0.002	1.061	29376.604	0.758
Non	1	0.000	0.004	0.001	1.783	844.500	0.915
additivity	21	0.003	0.003	0.003	1.026	30735.275	0.750

Residual

Yield per plant

Appendix 2. Meteorological data

Station: Rajshahi

Year	Month	Monthly average temperature		Relative Humidity (%)	Rainfall (mm)
		Max. (°C)	Min. (°C)		
2006	August	33.3	25.9	85	247
	September	32.9	25.5	86	302
	October	32.5	23.4	82	36
	November	28.7	17.8	80	10
	December	26.2	12.6	78	00
2007	January	24.4	9.4	75	00
	February	26.3	14.6	78	27
	March	31.1	17.1	66	59

Source: Bangladesh Meteorological Department, Agargaon, Dhaka

Appendix 3. Questionnaire on test and visual acceptability of ber Please

tick (V) the desire cultivar no. with desire component or group 1 .Fruit

texture :

- a) Highly acceptable (7) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
- b) Slightly acceptable (5) cultivar no.1, 2, 3, 4, 5,6, 7, 8, 9,10, 11,12
- c) Unacceptable (3) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

2.Juiciness:

- a) Highly acceptable (7) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10,11,12
- b) Slightly acceptable (5) cultivar no.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12
- c) Unacceptable (3) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12

3.Sweetness:

- a) Highly acceptable (7) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
- b) Slightly acceptable (5) cultivar no.1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12
- c) Unacceptable (3) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12

4.Market demand:

- a) Highly acceptable (7) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
- b) Slightly acceptable (5) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
- c) Unacceptable (3) cultivar no. 1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11,12