EVALUATION OF *NEIKUMBALAM* (*Benincasa hispida* Thunb.) COLLECTIONS FOR YIELD AND QUALITY

By

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(2015-12-008)

THESIS

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DECLARATION

I, **Manisha Elza Jacob** (2015-12-008) hereby declare that, this thesis entitled **"Evaluation of *neikumbalam* (*Benincasa hispida* Thunb.) collections for yield and quality"** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title of any other University or Society.

Place: Vellanikkara
Date: 6.11.2017

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2015-12-008

CERTIFICATE

Certified that this thesis entitled **"Evaluation of *neikumbalam* (*Benincasa hispida* Thunb.) collections for yield and quality"** is a record of research work done independently by **Ms. Manisha Elza Jacob (2015-12-008)** under my guidance and supervision and that, it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of **Ms. Manisha Elza Jacob (2015-12-008)**, a candidate for the degree of **Master of Science in Horticulture** with major field in **Plantation crops and Spices** agree that, this thesis entitled **"Evaluation of *neikumbalam* (*Benincasa hispida* Thunb.) collections for yield and quality"** may be submitted by Ms. Manisha Elza Jacob in partial fulfillment of the requirement for the degree.

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CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

Introduction

1. INTRODUCTION

Ash gourd [*Benincasa hispida* (Thunb.) Cogn.] is a member of the family Cucurbitaceae which is mainly grown for its fruits. It is a monoecious herb having a climbing or trailing habit (Rashid, 1993). Ash gourd fruit is known for its long storage life and good transport qualities, besides the nutritional and medicinal properties. The mature fleshy fruit is either eaten raw or after cooking or candied as sweet meat popularly known as 'petha'. Ash gourd is a good source of carbohydrates, vitamin A, vitamin C and minerals like iron and zinc (Randhawa *et al.*, 1983). The index of nutrition quality value (INQV) indicates that ash gourd is a quality vegetable due to the presence of various minerals and vitamins with a relatively high level of K and Na, low calorific value and no fat.

According to Ayurveda, ash gourd fruit has laxative, diuretic, tonic and aphrodisiac properties and is used in treatment of urinary discharges, calculi, thirst, biliousness, and blood and heart troubles. Ash gourd is valued in Ayurveda for its medicinal attributes for the cure of peptic ulcers (Grover *et al.*, 2001). The dilute juice of ash gourd is used for treating peptic ulcer. According to Unani system of medicine, the fruit is utilised as antiperiodic, cardiac, general tonic, aphrodisiac *etc.* Seeds have cooling properties and are useful in dry cough, fever, urethral discharges, biliousness, thirst *etc.* Seed oil, a potent source of vegetable oil and protein, is sweetish and good for brain and liver (Kalloo and Bergh, 1993).

The decoction of the fruit is anti-mercurial and is used as an antidote for alcoholic poisoning. The ash of fruit rind is applied on painful swellings. Ash gourd fruit is cooling and laxative thus increases the secretion and discharge of urine. It is also used for treating various ailments like constipation, piles, dyspepsia, syphilis and diabetes. Ash gourd being low in calories is useful for diabetic and obese people (Pandey *et al.*, 2015). The fruit juice is used in Ayurvedic medicine for treating a range of ailments including insanity and epilepsy (Ramesh *et al.* 1989). Rachchh and Jain (2008) reported the antiulcerogenic and antioxidant effect of petroleum ether and methanol extracts of *Benincasa hispida*.

13

Various workers have reported diversity in cultivars of ash gourd. Four recognized cultivars of ash gourd were identified by Walters and Decker-Walters (1989) namely, unridged winter melon, ridged winter melon, fuzzy gourd and wax gourd. Later, sixteen cultivars of *B. hispida* were reported by Marr *et al.* (2007) based on the shape, length and width and skin color of the fruit. Two cultivars of ash gourd, *i.e.* round shaped and elongated shaped are grown in Malaysia. Three cultivar types have been described by Morton (1971) in wax gourd on the basis of fruit shape and pubescence, namely, fruits nearly round and essentially hairless, fruits nearly round and hairy; and fruits oblong and hairy. Two types of ash gourd, *viz.* purple green coloured and green coloured were described by Chauhan (1989).

Vaidyakumbalam or *neikumbalam* is a specific ecotype of ashgourd in Kerala which is highly valued for its medicinal properties. The fruits of this ecotype, used for culinary purposes also, are hard pulped and have long keeping quality, with a size slightly larger than a cricket ball (Gopalakrishnan, 1957). *Neikumbalam* is the principal ingredient used in the preparation of the Ayurvedic medicine "*Kooshmanda rasayanam*" and "*poosanilehyam*", a similar preparation made by the Siddha medicine physicians (Subramanian *et al.*, 2013).

The availability of this special type of ash gourd is scarce at present. The vegetable type ashgourd is often used instead for medicinal preparations. There is an increasing importance for medicinal ash gourd nowadays due to its health benefits. Scattered attempts are being done at farmers'/ *vaidyas'* level to conserve and cultivate this unique ashgourd. However, not much is known about the morphology and biochemistry of *neikumbalam*. It is in this background that the present study was undertaken, with the following objectives:

1. To collect *neikumbalam* (*Benincasa hispida* (Thunb.) Cogn.) types from Kerala

2. To evaluate the collected types for yield and medicinal quality.

Review of literature

2. REVIEW OF LITERATURE

Ash gourd (*Benincasa hispida*) occupies a prominent position among the tropical cucurbitaceous vegetables. It is grown for its fruit, which is used in preparing confectionaries and in Ayurvedic medicinal preparations (Indira and Peter, 1987). Ash is also known as winter melon, ash pumpkin, white gourd, white pumpkin, gourd melon, tallow gourd, wax gourd and Chinese watermelon or Chinese preserving melon (Morton, 1971). The name wax gourd has been derived because of the thick waxy cuticle that typically develops on mature fruits. The available literature on *Benincasa hispida* has been reviewed in this chapter.

2.1 *Benincasa hispida*

Benincasa is a monotypic genus with the only cultivated species being *B. hispida*. The chromosome number is 2n=24 (Varghese, 1974; Seshadri, 1993). The specific epithet '*hispida*' refers to the hirsute pubescence on the foliage and immature fruits (Robinson and Decker-Walters, 1997), which are covered with long rigid hairs or bristles.

According to Gopalakrishnan (1957), a variety of *Benincasa hispida*, not previously recorded, known as medicinal ash gourd or *vaidyakumbalam/ neikumbalam* was found in cultivation in Malabar. This small fruited type with a thick rind, waxy coat and long keeping quality was considered important for its medicinal value. It was said to be used in Hindu medicine and was also suitable for culinary purposes. The shreddings of the hard pulp of this fruit was used for the preparation of Ayurvedic medicines like *kushmandalehyam*, *kusmandarasayanam* and *kushmandakhritham*.

16

2.1.1 Botanical classification

The plant is categorized taxonomically as:

Kingdom : Plantae (Plants)

Sub-kingdom : Tracheobionta (Vascular plants)

Superdivision : Spermatophyta (Seed plants)

Division : Magnoliophyta (Flowering plants)

Class : Magnoliopsida (Dicotyledons)

Family : Cucurbitaceae

Genus : *Benincasa*

Species : *Benincasa hispida* (Thunb.) Cogn.

2.1.2 Origin and species diversity

Ash gourd is believed to have originated in South Asia and South East Asia. Indo-China is the centre of diversity for ash gourd (Rubatzky and Yamguchi, 1997). Simmonds (1976) reported that ashgourd is indigenous to Asian tropics. It has also been reported that it is probably a native of Malaysia and cultivated forms may have originated in South East Asia (Peter, 1998). Ash gourd is extensively grown throughout the tropical and subtropical regions of India.

Four recognized cultivars of ash gourd have been identified by Walters and Decker-Walters (1989) namely, unridged winter melon, ridged winter melon, fuzzy gourd and wax gourd. Later, sixteen cultivars of *B. hispida* were reported by Marr *et al.* (2007) based on the shape, length and width and skin color of the fruit. Two cultivars of ash gourd, *i.e.* round shaped and elongated shaped are grown in Malaysia. The round shaped fruit is the cultivated type and is used for commercial purposes.

Wild populations of the small fruited type, classified as *Benincasa hispida* var *pruriens* (Parkinson) Whistler, are found in several islands in the South Pacific (Whistler, 1990). These have also been reported in Australia, Indonesia, Japan and Southern China.

Three cultivar types have been described by Morton (1971) in wax gourd on the basis of fruit shape and pubescence, namely, fruits nearly round and essentially hairless, fruits nearly round and hairy; and fruits oblong and hairy. Two types of ash gourd, *viz.* purple green coloured and green coloured were described by Chauhan (1989).

2.2 Morphological characters

2.2.1 Habit

Ash gourd is a vigorous but slow growing trailing annual with long tap root system. All parts of the plant, including stem and leaves are covered with bristle-like hairs.

2.2.1.1 Vine length

In a study by Nagaraju *et al.* (2016), it was observed that the average vine length in *vaidyakumbalam*, the medicinal type of ash gourd, and several other ash gourd accessions were found to be similar. Variability in vine length in ash gourd was reported by Afroze (2006), Singhal (2008), Dobre (2013) and Dewan *et al.* (2013). The vine length in exotic monoecious genotypes of ash gourd at first male flower opening was much less in comparision to local genotypes (Latif *et al.*, 2008).

2.2.1.2 Number of primary branches

Wide variability in the number of primary branches per vine in ash gourd was reported by Gangopadhyay *et al.* (2008), Pandey *et al.* (2008), Singhal (2008), Dobre (2013), Rao and Sushama (2014), Sahu *et al.* (2015) and Bairwa (2016).

Primary branches were less in number in *vaidyakumbalam* than several *Benincasa hispida* accessions in a study by Nagaraju *et al.* (2016).

2.2.2 Floral characters

Ash gourd is a monoecious crop which produces large male flowers with long pedicels and female flowers with densely haired ovary and short peduncle. The petals are large and yellow in colour.

2.2.2.1 Days to first male flower

Studies by Afroze (2006), Pandey *et al.* (2008), Singhal (2008) and Bairwa (2016) revealed the variability in the number of days to opening of first male flower in ash gourd. Hamid *et al.* (1989) studied some local ash gourd genotypes for two years and observed that the days to opening of first male flower was higher in the second year. Latif *et al.* (2008) reported that the time required for opening of first male flower in exotic ash gourd genotypes was lesser than local genotypes.

2.2.2.2 Days to first female flower

Days to first female flower in ash gourd showed variation, as studied by Afroze (2006), Pandey *et al.* (2008), Singhal (2008) and Bairwa (2016). According to Hamid *et al.* (1989), the days to first female flower opening was higher in the second year crop than first year in ash gourd. Anthesis of the first female flower of exotic types took place much earlier than the local types (Latif *et al.*, 2008). It was also reported that *vaidyakumbalam* recorded higher number of days to first female flower than other ash gourd accessions (Nagaraju *et al.*, 2016).

2.2.2.3 Number of nodes to first male flower

Variability was observed by Rashid (1993), Afroze (2006), Pandey *et al.* (2008), Singhal (2008), Rao and Sushama (2014), Sahu *et al.* (2015) and Bairwa (2016) for the node number at which the first male flower appeared in ash gourd.

Hamid *et al.* (1989) reported that the node number of the first male flower in ash gourd genotypes was higher in second year than first year in a two-year study. He also found that the node number was lower in local genotypes. However, it was observed that the first male flower was borne in a lower node number in exotic types compared to local genotypes of ash gourd (Latif *et al.*, 2008).

2.2.2.4 Number of nodes to first female flower

Studies by Afroze (2006), Gangopadhyay *et al.* (2008), Pandey *et al.* (2008), Singhal (2008), Rao and Sushama (2014), Sahu *et al.* (2015) and Bairwa (2016) showed the variability in the number of nodes to first female flower in ash gourd. The first female flower was produced at a lower node in *vaidyakumbalam* than other ash gourd accessions (Nagaraju *et al.* 2016).

Latif *et al.* (2008) noted that both in exotic and local genotypes of ash gourd, the male flowers appeared earlier at lower node as compared to the female flowering node. And, female flowers appeared at lower nodes in exotic materials compared to local genotypes.

2.2.2.5 Sex ratio

Rashid (1993) reported that the number of staminate flowers was many folds than pistillate ones and the ratio depended on the genotypes and surrounding environment. The number of female flowers was found to be more in exotic genotypes of ash gourd than local types (Latif *et al.*, 2008). The sex ratio (number of male flowers per female flower) was found to be more in *vaidyakumbalam* than

other ash gourd accessions (Nagaraju *et al.*, 2016). Variability in this parameter in ash gourd was reported by many scientists, *viz.* Randhawa *et al.* (1982), Seshadri (1986) and Dewan *et al.* (2013).

2.2.2.6 Variability in morphological characters in other cucurbits

Genetic variability was reported in pumpkin for main vine length (Rana *et al.* 1986). However, Saha *et al.* (1992) did not find significant differences among the pumpkin lines for this parameter. A field experiment was conducted by Swamy *et al.* (1984) in muskmelon and he reported genetic diversity for vine length of this crop.

Rahman *et al.* (1986) concluded that days to male flowering were lesser than those to female flowering in several cucurbit genotypes like ribbed gourd, bitter gourd and sweet gourd.

2.3 Fruit characters of ash gourd

Mature fruits of ash gourd are called winter melons as they can be stored for as long as a year. The waxy coating prevents the loss of moisture and protects it from insects and microorganisms (Morton, 1971). The fruit when young is green coloured and covered with pointed whitish hair, which on ripening becomes smooth and gets covered with a bluish white wax. This waxy coating ensures its outstanding storage quality (Seshadri, 1986). Purseglove (1987) also reported that mature fruits are covered with white wax. The endocarp is the edible portion of this fruit (Rashid, 1993).

2.3.1 Fruit shape

Enormous variability was observed in fruit shape in ash gourd, *i.e.* oblong, oblate (Seshadri, 1986), cylindrical, spindle shaped, round (Gangopadhyay *et al.*,

2008), long, oblong, round oblong, round, flat round (Singhal, 2008), cylindrical and club shaped fruits (Bairwa, 2016).

2.3.2 Flesh colour of fruit

The flesh of the mature fruit is spongy and juicy. The flesh colour of fruits exhibited various colour in different genotypes, the cream and white flesh colour being very common and yellow colour was rare (Dewan *et al.*, 2013).

2.3.3 Flesh thickness

Variability for flesh thickness was reported by Pandey *et al.* (2008), Singhal (2008) and Dewan *et al.* (2013).

2.3.4 Fruit length

Studies by Afroze (2006), Gangopadhyay *et al.* (2008), Pandey *et al.* (2008), Latif *et al.* (2008), Singhal (2008), Dewan *et al.* (2013), Sahu *et. al.* (2015) and Bairwa (2016) reported variability in fruit length in ash gourd. Fruits of *vaidyakumbalam* were shorter than those of other ash gourd accessions (Nagaraju *et al.*, 2016). Srivastava and Srivastava (1976) reported variation in fruit length and diameter in ash gourd.

2.3.5 Fruit diameter

Great variability in fruit size of ashgourd was reported by several workers (George, 1981; Randhawa *et al.*, 1983; Hamid *et al.*, 1989; Mandal *et al.*, 2002). Variability in fruit diameter was observed by Arora *et al.* (1983), Gangopadhyay *et al.* (2008), Latif *et al.* (2008), Pandey *et al.* (2008), Singhal (2008), Dewan *et al.* (2013), Dobre (2013), Sahu *et. al.* (2015) and Bairwa (2016). Fruit diameter in

vaidyakumbalam was lesser than that in other ash gourd accessions (Nagaraju *et al.*, 2016).

2.3.6 Fruit weight

Variability in fruit weight of ash gourd was observed by Chowdhury (1967), Katayal (1985), Gopalakrishnan *et al.* (1987), (Afroze, 2006), Gangopadhyay *et al.* (2008), Latif *et al.* (2008), Pandey *et al.* (2008), Singhal (2008), Dewan *et al.* (2013), Dobre (2013), Rao and Sushama (2014), Sahu *et. al.* (2015) and Bairwa (2016). Fruits of local genotypes of ash gourd were found to be heavier than exotic genotypes in a study by Rahman (1996). A wide range of variability for fruit bearing, fruit weight and fruit size in a collection of a local germplasm of ashgourd was reported by Hamid *et al.* (1989). The fruits of *vaidyakumbalam* had much lesser fruit weight than several other ash gourd accessions (Nagaraju *et al.*, 2016).

2.3.7 Number of fruits per plant

Variability in the number of fruits per plant in ash gourd was observed by Afroze (2006), Gangopadhyay *et al.* (2008), Latif *et al.* (2008), Pandey *et al.* (2008), Singhal (2008), Dewan *et al.* (2013), Dobre (2013), Rao and Sushama (2014), Sahu *et al.* (2015) and Bairwa (2016).

2.3.8 Yield per plant

The variation in the yield per plant in ash gourd was reported by Afroze (2006), Pandey *et al.* (2008), Singhal (2008), Rao and Sushama (2014), Sahu *et al.* (2015) and Bairwa (2016).

Raveendran (2003) studied growth behaviour and yield of *neikumbalam* in the interspaces of young and mature oil palm plantations and under open conditions.

Neikumbalam was suitable as an intercrop in young oil palm plantations. But, the yield per plant under mature oil palm was very low.

2.3.9 Days to fruit maturity

Variability in days to first fruit set and days to first fruit harvest was observed by Sahu *et al.* (2015) and Bairwa (2016).

2.3.10 Variability in fruit characters in other cucurbits

Variability was observed for fruit shape in watermelon (Gill and Kumar, 1986) and pumpkin (Chigwe, 1991).

Mangal *et al.* (1983) reported significant variation for fruit length and diameter in bitter gourd.

Rahman *et al.* (1990) found significant variation among bitter gourd and sweet gourd genotypes for fruit size.

Doijode and Sulladmath (1986), Rana *et al.* (1986) and Saha *et al.* (1992) reported variability in fruit weight of pumpkin. Significant variations were also reported in ribbed gourd, bitter gourd and pumpkin (Rahman *et al.*, 1990).

A wide range of variability for fruits per plant was also found in bottle gourd (Tyagi, 1972), sponge gourd (Arora *et al.*, 1983), watermelon (Vashistha *et al.*, 1983), round melon (Dahiya *et al.*, 1989), bitter gourd (Sharma and Bhutani, 2001) and pumpkin (Chandrakumar, 2006).

2.4 Crop duration

Sahu *et al.* (2015) and Bairwa (2016) reported the narrow variation present in the parameter, crop duration among different ash gourd genotypes.

2.5 Seed characters

White or yellowish white seeds are filled in the center of ash gourd (Morton, 1971; Retnam and Martin, 2006). The seed color changes from white to yellowish brown as the fruit matures. The seeds are ovate, elliptical, flattened and sometimes prominently ridged (Grubben, 2004).

2.5.1 Number of seeds per fruit

Number of seeds in ash gourd fruits was variable, as reported by Afroze (2006), Gangopadhyay *et al.* (2008), Singhal (2008) and Bairwa (2016). *Vaidyakumbalam* fruits had lesser number of seeds than fruits of other ash gourd accessions (Nagaraju *et al.*, 2016).

2.5.2 Hundred seed weight

Afroze (2006), Sahu *et al.* (2015) and Bairwa (2016) reported variability in hundred seed weight of ash gourd seeds.

2.5.4 Variability in seed characters in other cucurbits

Mannan (1992) observed significant differences among bitter gourd genotypes for seeds per fruit.

Chhonkar (1977) found narrow range of variability for hundred seed weight in watermelon. Similarly, Swamy *et al.* (1984) found a wide range of variability among the some muskmelon genotypes for seed weight per fruit.

Vashistha *et al.* (1975) reported wide variation in length and breadth of seeds in watermelon.

2.6 Cultivation of ash gourd

2.6.1 Climate and season

The plants belonging to Cucurbitaceae are frost-sensitive, drought-tolerant, and intolerant to wet and poorly drained soils (Whitaker and Bohn, 1950). They are cultivated upto an altitude of 1500 m above mean sea level. The crop comes up very well in humid and high rainfall areas also. The ideal temperature for growth and production is 24-30°C. The crop is grown throughout the year in areas with a mild winter season. As a rainfed crop, it is sown by May in Kerala and by June-July in Tamil Nadu. In North India, it is mainly grown during summer and rainy seasons.

2.6.2 Seed extraction and propagation

Fruits are allowed to mature till vines and fruit stalks are completely dried when grown for seed purpose. After reaching maturity, the fruits are preserved for 2-3 months before extraction of seeds. Seeds along with placenta are scooped out from cut fruits and allowed to ferment overnight. Seeds are then washed in running water and allowed to dry. Seeds after extraction are preserved for 2-3 months before sowing.

Germination of seeds extracted from freshly harvested fruits is very low because of dormancy. Three types of dormancy have been reported in cucurbits, *viz.* exogenous dormancy (due to impermeable seed coat to water, oxygen and carbon dioxide), endogenous dormancy (due to physiological inhibition caused by chemical inhibitors present in seeds) and a combination of the first two factors (Hartmann *et al.*, 1997; Geneve, 1998).

2.6.3 Harvest

Fruits are harvested at immature and fully mature stages depending on the requirement. Immature fruits are harvested one week after anthesis and harvesting is

done at weekly intervals. Mature fruits for storage, long distance transport and for seed extraction are harvested after full development of waxy coating on fruit surface.

2.7 Pests and diseases of ash gourd

Robinson and Decker-Walters (1997) reported no serious diseases and relatively few pest problems in ash gourd. Common pests of this crop are fruit flies attacking young fruits, red pumpkin beetles and aphids attacking tender seedlings and jassids attacking the mature leaves (Morton, 1971). Ash gourd is sometimes used as a rootstock for grafted melon because of its resistance to soil-borne diseases.

2.8 Composition of ash gourd fruit

The active principles of ashgourd are present in the cortical region, bark, stem, leaves, flowers, fruits, seeds *etc*. The main phytoconstituents of therapeutic significance present in the fruit comprise of carbohydrates, glycosides, tannins and phenolic compounds, lipids, volatile oils, resin and resin combinations and alkaloids (Handa and Kapoor, 1999).

Fruits contain on an average 96.7 % moisture, 1.9 g carbohydrate, 0.4 g protein, 0.1 g fat, 0.06 mg thiamine, 0.01 mg riboflavin, 1 mg vitamin C, 36 mg calcium, 0.8 mg iron and 10 cal of energy per 100 g of edible portion (Gopalan *et al.*, 1997).

2.8.1 Moisture

Moisture content accounts for more than 90 per cent of the edible weight portion in both immature and mature fruits. The moisture level increases as the fruit matures.

2.8.2 Protein and amino acids

Mingyu *et al.* (1995) and Aqilah *et al.* (2011) reported that total protein and free amino acids were present in high amounts in seed, and were lowest in amount in the pulp. Proteins are present within the range of 0.3 to 0.5% of an edible portion of the fruit pulp. Protein content was found to be more in the fruit immediately after harvest than after 75 days (Pandey *et al.*, 2009). Nagaraju *et al.* (2016) observed that protein content in *vaidyakumbalam* was lesser than that in other ash gourd accessions.

2.8.3 Total ash

The amount of total ash in ash gourd fruit is within the range of 0.3 to 0.5 % of the fruit pulp (Dobre, 2013).

2.8.4 Sugars

Mazumder *et al.* (2005) reported that ash gourd is an important source of water soluble polysaccharides. According to Wills *et al.* (1984), natural sugars like glucose and fructose are present in immature and mature fruit pulp. The levels of these sugars were found to reduce as the fruit matured. In another study, the content of total sugar, reducing sugar, and non-reducing sugar was found to increase on storage (Pandey *et al.*, 2009).

2.8.5 Phenols

The total phenol content in different extracts of ash gourds were estimated by Pandey *et al.* (2009). Ethanolic extract had maximum phenol content than aqueous extract and ethyl acetate extract, with the least in ethyl acetate extract.

2.8.6 Antioxidant property

Estimation of antioxidant property expressed by different extracts of ash gourd revealed that IC 50 value was highest for ethyl acetate extract, followed by aqueous extract and ethanolic extract (Pandey *et al.*, 2009).

2.8.7 Seed oil

Ash gourd seed is one of the best cucurbit seed oil sources for the hot and humid tropics (Martin, 1984). It was reported in a study by Sew *et al.* (2010) that this seed oil contains high proportion of linoleic acid accounting for 67.37% of the total fatty acids.

2.9 Health benefits and medicinal uses of ash gourd

The Chinese used ashgourd for a range of medicinal purposes (Yang and Walters, 1992). Kumar and Vimalavathini (2004) reported ash gourd as an important ingredient of *kushmandalehyam,* an Ayurvedic medicine. Similarly, the 'Donguibogam', an old Korean medical encyclopedia mentions the use of this fruit against dropsy, diseases related to liver, leucorrhea, fever, for detoxification of minerals, strengthening the functions of the bladder and small and large intestines (Choi *et al.*, 2001).

Benincasa hispida has been used for the treatment of *diabetes mellitus*, diuresis diseases, urinary infection, chronic inflammatory disorders, peptic ulcer and internal organ haemorrhages (Grover and Rathi, 1994 and Lee *et al.*, 2005). It has also been widely used as a therapeutic agent for the treatment of epilepsy and other nervous disorders (Asolkar *et al.*, 1992). Ash gourd fruit juice and extract has significant anti-ulcer, anti-depressant and diuretic activities (Mingyu *et al.*, 1995), and provides protection against histamine-induced bronchospasm (Kumar and Ramu, 2002). Huang *et al.* (2004) have reported about its use to treat hypertension and inflammation. Ripe fruits of ashgourd were found to be useful for treating

tridoshas, insanity, epilepsy and other nervous disorders (Sanyal, 1984 and Saimbhi, 1993).

Ash gourd fruit powder helps in increasing blood count and is used in treating anaemia (Supreeja, 2002). Ashgourd fruit paste can be used in case of burns, cuts and minor wounds (Mathewkutty, 1996). Tender stems are found to be effective for liver troubles and muscular pain. The seed powder is antihelmintic (Agarwal, 1997). Seeds are vermifuge and are useful in treating difficult urination and removal of bladder stones (Sivarajan and Balachandran, 1994). Seed kernel can be used against skin eruption and is one of the ingredients used in drug preparation for appendicitis (Asolkar *et al.*, 2000).

Materials and methods

3. MATERIALS AND METHODS

The study entitled "Evaluation of *neikumbalam* (*Benincasa hispida* Thunb.) collections for yield and quality" was carried out in the Department of Plantation Crops and Spices at College of Horticulture, Vellanikkara, during September 2016 to January 2017.

3.1 Experimental site

The experimental field is located at an altitude of 22.5 m above mean sea level between 10°32' latitude and 76°16' longitude. The area lies in tropical monsoon climatic region with more than 80 % of rainfall distributed through south west and north east monsoons.

3.2 Experimental material

The experimental material for this study comprised of sixteen collections of *neikumbalam* (medicinal ash gourd) from different locations in Kerala. A survey was conducted for collecting the germplasm of medicinal ash gourd grown in different locations in Southern, Central and Northern Kerala. The details of the collected types are given in Table 3.1.

3.2.1 Design of experiment

The experimental design and layout are given below:

Number of collections : 16

Design : RBD

Replications : 2

Check variety : Indu

32

Table 3.1 *Neikumbalam* collections used for study

Accession No	Source/ location
BH 1	West Eleri (Kasaragod)
BH 2	Potta (Thrissur)
BH 3	Kottamuri (Thrissur)
BH 4	Mallapally (Pathanamthitta)
BH 5	North Paravur (Ernakulam)
BH 6	Vellarikundu (Kasaragod)
BH 7	Kannara (Thrissur)
BH 8	Kanjirapoyil (Kasaragod)
BH 9	Charamangalam (Alapuzha)
BH 10	Areeparambu (Alapuzha)
BH 11	Kattakkada local (NBPGR, Thrissur)
BH 12	Perumbilisherry (Thrissur)
BH 13	IC-613454 (NBPGR, Thrissur)
BH 14	IC-0596939 (NBPGR, Thrissur)
BH 15	Thannyam (Thrissur)
BH 16	IC- 0596993 (NBPGR, Thrissur)
Check	Indu (KAU variety)

Season : Kharif 2016

Spacing : 4.5 m x 2 m

Number of plants/replication : 5

3.2.2 Extraction of seed

The seeds along with the mucilage was scooped out from the collected fruits, washed well and dried. This was stored for two months prior to sowing.

3.2.3 Raising of seedlings

Seedlings were raised by sowing the seeds in 98-celled portrays at the rate of one seed per cell. The growing medium was prepared by mixing coir pith, vermiculite and perlite in the ratio 3:1:1 by volume. The seeds were allowed to germinate under sufficient moisture.

3.2.4 Transplanting

Seedlings (15 to 20 day old) after reaching four-leaf stage were transplanted to the experimental plot. Five plants of each collected type per replication were planted maintaining the spacing.

3.2.5 Field preparation

The field was ploughed and levelled well. The layout of prepared field was done as per the experimental design. Field was divided according to treatments and replications with randomized block design. The field was protected from all four sides by fencing and covering with net on the sides and top.

3.2.6 Intercultural operations

Necessary intercultural operations were carried out during the cropping period for proper growth and development of the plants. The plants were irrigated daily. Other intercultural operations like weeding and plant protection measures were adopted as and when needed. Recommended dose of fertilizers and other cultural package of practices were adopted for better crop growth as per POP recommendations of KAU (2016).

3.3 Observations recorded

3.3.1 Morphological characters

The following morphological characters were recorded and average value was calculated.

3.3.1.1 Days to 50 per cent germination

Seeds extracted from the collected types were sown in protrays. The percentage of seeds germinated and the number of days taken for it were recorded.

3.3.1.2 Vine length

The length of the main vine from the base of the plant upto the tip was measured in centimeters, during four growth stages, *viz.* pre flowering stage, flowering stage, fruiting and harvest stage. Observations at pre flowering stage were recorded 35 days after sowing.

3.3.1.3 Number of primary branches

The number of branches per plant from the base of the plant upto the tip was counted at four growth stages *viz.* pre flowering stage (35 days after sowing), flowering stage, fruiting and harvest stage.

35

3.3.1.4 Number of leaves

The number of leaves in each plant was counted at pre flowering stage (35 days after sowing), flowering stage, fruiting and harvest stage.

3.3.1.5 Leaf area

The leaf area (cm^2) of four randomly selected leaves from each plant at flowering stage was measured using millimeter graph paper method and average leaf area per plant was calculated.

3.3.1.6 Days to first male flower

Number of days taken for opening of the first male flower was recorded from the date of sowing of seed.

3.3.1.7 Days to first female flower

Number of days taken for opening of the first female flower was recorded from the date of sowing of seed.

3.3.1.8 Node to first male flower

The node number at which the first male flower appeared was noted, counting from the base of the plant.

3.3.1.9 Node to first female flower

The node number at which the first female flower appeared was noted, counting from the base of the plant.

3.3.1.10 Number of male flowers

Total number of male flowers borne on the plant over the growth period was recorded.

3.3.1.11 Number of female flowers

Total number of female flowers borne on the plant over the growth period was recorded.

3.3.1.12 Sex ratio

Sex ratio for each plant was derived by calculating the number of male flowers borne per female flower.

3.3.1.13 Fruit set per cent

Fruitset percent was calculated by calculating the proportion of female flowers that developed to fruits.

3.3.1.14 Fruits/ plant

Total number of fruits borne per plant was recorded.

3.3.1.15 Fruit yield

The fruit yield per plant was calculated by summing up the weights of all fruits on the plant after last harvest.

3.3.1.16 Days to maturity

Days to fruit set were recorded for each plant from sowing to the date of first fruit set. Days to fruit harvest were recorded as number of days taken from the date of sowing to the date of harvesting of mature fruits from the plants. Days to fruit maturity was calculated by subtracting the former from the latter.

3.3.1.17 Crop duration

Crop duration was recorded as the number of days from sowing to last harvest.

3.3.1.18 Disease/ pest incidence

Incidence of pest and disease attack during the growth period was observed. Suitable control measures were adopted as required.

3.3.2 Fruit characters

Fully mature fruits were harvested upon the drying up of petiole. These fruits were used for recording observations on fruit characters.

3.3.2.1 Fruit shape

The fruits were categorized based on their shape as:

a. Oblong

b. Spherical

c. Conical

3.3.2.2 Waxiness

The intensity of waxiness over the mature fruit surface was recorded and categorized as:

a. Low

b. Medium

c. High

3.3.2.3 Hairiness

The intensity of the hairs over the fruit surface was noted and categorized as:

a. Low

b. Medium

c. High

3.3.2.4 Rind colour

The rind colour of the cut open fruits was categorized as:

a. Bright green

b. Light green

c. Dark green

d. Yellowish green

3.3.2.5 Keeping quality

The keeping quality of fruits under ambient conditions was noted.

3.3.2.6 Fruit length

The length of fruits was measured from stem end to apex and expressed in centimeters.

3.3.2.7 Fruit diameter

The fruit diameter was measured as the girth of the fruit at the centre and expressed in centimeters.

3.3.2.8 Fruit weight

Average weight of fruits was recorded in grams.

3.3.2.9 Rind thickness

The thickness of the rind of cut open fruit was measured in millimeters.

3.3.2.10 Flesh thickness

The flesh thickness of the cut open fruits from both the equatorial and polar sides was measured in millimeters and average of these two was calculated to obtain the average flesh thickness.

3.3.3 Seed characters

Seeds were extracted from the cut open fruits along with the mucilage. It was washed well, dried under shade and the following seed characters were recorded.

3.3.3.1 Number of seeds

The number of seed per fruit was recorded in each fruit and average value was calculated.

3.3.3.2 Seed size

The seed dimensions, *i.e.* length and breadth were measured and expressed in millimeters.

3.3.3.3 Weight of seed coat

The dried seeds were split open and the seed coat and kernel were separated. The seed coat weight was then measured in mg using electronic balance.

3.3.3.4 Weight of kernel

The seed kernel weight was measured in mg using electronic balance.

3.3.3.5 Hundred seed weight (fresh)

The hundred seed weight of freshly extracted seeds was recorded using electronic balance and expressed in grams.

3.3.3.6 Hundred seed weight (dry)

The hundred seed weight of seeds after shade drying was recorded using electronic balance and expressed in grams.

3.3.3.7 Seed viability (under ambient conditions)

Seed viability was tested two months after seed extraction using Tetrazolium test. The seeds were soaked in water for softening the seed coat after which they were split open using a scalpel. The split open seeds were placed in 2, 3, 5-triphenyl tetrazolium chloride solution (1%) in a petridish. The percentage of stained embryos was recorded after 24 hours, which was used to calculate seed viability in per cent.

3.3.3.8 Kernel oil

The volatile oil present in seed kernel was extracted by using Clevenger's apparatus through hydro distillation method (Clevengers, 1982). 10 g of powdered sample was mixed with 250 mL of distilled water and fed to the round bottom flask attached to the Clevengers apparatus with condenser. The flask was then gently heated upto a temperature of 70°C to 80°C and continued for 4 hours. The oil after collecting at the receiver end was cooled to room temperature. The volume of oil collected was expressed as per cent volume per unit mass of sample.

$$\text{Volatile oil} = \frac{\text{Volume of oil collected (mL)} \times 100}{\text{Total weight of sample (g)}}$$

3.3.4 Phytochemical screening

The presence of various active components was tested by the procedure described by Kokate (2000) and Harborne (1999). Samples were dried and powdered after which they were soaked in ethanol in 1:1 ratio. The filtrate obtained from this was used for phytochemical analysis. The tests carried out were:

3.3.4.1 Test for steroids

The sample extract (1 mL) taken in a test tube was added with 1 mL acetic acid, 1 mL chloroform followed by 0.5 mL sulphuric acid. The formation of violet to blue green colour denoted the presence of steroids.

3.3.4.2 Test for tannins

A few drops of 1 % lead acetate were added to 2 mL extract. Appearance of yellowish precipitate indicated presence of tannin.

3.3.4.3 Test for total phenols

One mL of extract in test tube was treated with 3 % ferric chloride. The solution turning blue in colour indicated the presence of phenol.

3.3.4.4 Test for cycloglycosides

Two mL of acetic acid was added to 5 mL of extract followed by 1 % ferric chloride. The turning of solution to brownish violet ending up with greenish ring formation on adding one drop sulphuric acid, indicated the presence of cycloglycosides.

3.3.4.5 Test for saponins

To one mL of extract, five mL of distilled water was added and shaked vigorously for 2 minutes. The appearance of foam which persists for at least 15 minutes confirmed the presence of saponins.

3.3.5 Biochemical characters

Fully mature fruits were used for estimating the biochemical characters.

3.3.5.1 pH of fruit juice

The weighed fruit sample (10g) was macerated with 100 mL of water and allowed to stand for 30 minutes. The supernatant was decanted into a beaker and the pH of this solution was determined using a pH meter.

3.3.5.2 Titrable acidity

The sample (1g) was ground with little amount of water in a mortar and pestle. The volume was made upto 100 mL in a standard flask after filtering. 10 mL of this solution was pippetted out in a conical flask and one drop of phenolphthalein indicator was added to it. This was titrated against 0.1 N sodium hydroxide (0.2 g in 100 mL). The appearance of light pink colour is the end point.

Titrable acidity =

$$\frac{\text{Titre value x Normality x Volume made up x Equivalent weight of acid x 100}}{\text{Weight of sample x 1000}}$$

3.3.5.3 Total minerals

The fruit sample after drying and powdering (3-5 g) was taken into a pre weighed silica crucible. The weight of the crucible along with the sample was noted down. The silica crucible with the decarbonized sample was transferred to a muffle furnace and ignited at 550-600°C for 2-3 hours until no black particles were left. The crucible with ash was cooled in a dessicator and the weight was noted quickly.

The total ash /mineral content was the calculated as,

$$\text{Total ash} = \frac{c - a}{b - a} \times 100$$

where a: Empty weight of silica crucible

b: Weight of crucible with sample

c: Weight of crucible with ash

3.3.5.4 Total free amino acids

The total free amino acids content was estimated by the method described by Sadasivam and Manickam (1992) using ten per cent iso-propanol as the solvent. A quantity of 500 mg of the fresh sample was weighed and ground well with 5 mL of 10 % isopropyl alcohol. This was centrifuged and supernatant was saved. The extraction was repeated and supernatants were pooled. Sample extracts of 0.5 mL and working standards of 0.2 to 1 mL were pippetted out into a series of test tubes. The blank was set with 0.1 mL of 80 % methanol. A volume of 1 mL Ninhydrin solution was added to all the tubes and made to 2 mL with distilled water. The tubes were heated in boiling water bath for 20 minutes. This was cooled and 5 mL of diluent solvent was added. The contents were mixed well. After 15 minutes, on development of blue colour, absorbance was noted at 570 nm.

3.3.5.5 Protein

The protein content was estimated by Lowry's method described by Sadasivam and Manickam (1992). The fresh plant sample was ground using tris buffer and centrifuged at 4°C. The supernatant obtained was used for protein estimation. Working standards from 0.2 mL to 1 mL and 0.5 mL of sample extracts

were pippetted out into a series of test tubes. The volume in each tube was made to 1 mL with distilled water. The blank was set with 1 mL distilled water. A volume of 5 mL alkaline copper solution was added to all the tubes. It was mixed well and allowed to stand for 10 minutes. A volume of 0.5 mL of Folin Ciocalteu reagent was added to all the tubes. It was mixed well and incubated at room temperature in dark for 30 minutes. After the development of blue colour, absorbance was recorded at 660 nm.

3.3.5.6 Total sugars

Total sugars present in the sample were estimated via phenol sulphuric acid method (Nielson, 2010). The sample homogenized in 80% methanol and centrifuged was used for estimation. Working standards from 0.2 to 1 mL and sample extracts of 0.5 mL were pippetted out into a series of test tubes. The volume in each of the tubes was made upto 1 mL with distilled water. To each test tube, 1 mL of phenol solution (5 %) was added followed by 5 mL of 96 % sulphuric acid. The tubes were shaken well and kept for 10 minutes. It was placed in a water bath at 25-30 °C for 20 minutes to develop a light yellowish brown colour. Test tubes were cooled and absorbance was read at 490 nm.

3.3.5.7 Starch

Starch content in the samples was estimated by Anthrone reagent method given by Hedge and Hofreiter (1962). The sample (0.5 g) was homogenized in hot 80 % ethanol to remove sugars. The sample along with ethanol was centrifuged and residue was retained. Residue was washed repeatedly with hot 80 % ethanol and dried over water bath. A volume of 5 mL of water and 6.5 mL of 52 % perchloric acid were added to this. This was centrifuged for 20 minutes at 0°C and supernatants were pooled. The extraction was repeated using fresh perchloric acid and made upto 100 mL. The supernatant (0.1 to 0.2 mL) was pippetted and made upto 1 mL with water. The standards were prepared by taking 0.2, 0.4, 0.6, 0.8 and 1 mL of working standard and made upto 1 mL with water. 4 mL of anthrone reagent was added to

each tube. All test tubes were then heated in water bath. After cooling the tubes, the intensity of green to dark green colour was read at 630 nm.

3.3.5.8 Total phenols

Total phenol content of the sample extracts was estimated using Folin-Ciocalteau reagent as per the method described by Sadasivam and Manickam (1992). The extracts, after mixing with Folin-Ciocalteau reagent and sodium carbonate (20%) were incubated at room temperature for 30 minutes and absorbance read at 650 nm using a spectrophotometer. Total phenolic values were expressed (mg/mL) in terms of tannic acid equivalents as standard.

3.3.5.9 Tannins

The tannin content was estimated by Folin Denis method given by Schandrel (1970). A quantity of 0.5 g of sample was transferred to a conical flask and 75 mL of water was added. The flask was heated gently for 30 minutes and centrifuged at 2000 rpm for 20 minutes. The resultant supernatant was collected in 100 mL volumetric flask and made upto the volume. The sample extract (1 mL) was transferred to a container and 100 mL water was added. To this, 5 mL of Folin Denis reagent and 10 mL of sodium carbonate solution were added and diluted to 100 mL with water. After shaking thoroughly, the absorbance was read at 700 nm after 30 minutes.

3.3.5.10 Antioxidant activity

The fruits of the sample were dried and powdered after which sample extraction was done using Soxhlet apparatus through solvent extraction method with ethanol as the solvent. The powdered sample was weighed (5 grams) and packed in thimble and placed in extraction tube. 100 mL of ethanol was added to extraction tube and kept in water bath after placing condenser on top. The extraction was carried out till no colour was observed for solvent in extraction tube. At the final stage of extraction, the thimble was removed and it was evaporated to remove traces of solvent.

The free radical scavenging activity of these sample extracts based on the scavenging activity of the stable 1,1-diphenyl-2-picryl hydrazyl (DPPH) free radical was determined by the method described by Braca *et al.* (2001). A stock solution of 1000 ppm concentration was prepared from the extracted sample. Different concentrations of sample extracts were prepared from this stock (50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm and 300 ppm). Each tube was made upto 5 mL with methanol. From each of this solution, 2.8 mL was pippetted and 200 microlitres (2 mg/ 4 mL) of DPPH reagent was added to each. These were kept in dark for 30 minutes. The colour of the purple solution changes to yellow depending upon the free radical scavenging ability of the sample extract. The absorbance at 517 nm was recorded after keeping in dark for 30 minutes. The percentage of DPPH quenched was calculated as

$$\frac{\text{OD of blank} - \text{OD of sample} \times 100}{\text{OD of blank}}$$

A graph was plotted using these values and IC 50 value of the sample was determined as 50/ slope.

3.4 Statistical analysis

The analysis of variance was carried out for each character separately as per method suggested by Panse and Sukhatme (1967). Significance of differences among genotypes was tested.

Results

4. RESULTS

This study has dealt with the evaluation of sixteen *neikumbalam* collections for yield and quality. These accessions along with a check variety 'Indu' were evaluated for various morphological, fruit, seed and biochemical characters. The observations on these parameters were statistically analysed to understand variability among the collection and the results have been explained below.

4.1 Morphological characters

The morphological characters of the *neikumbalam* accessions and the check variety 'Indu' from sowing to harvest recorded during the study are described below.

4.1.1 Seed germination

Data on seed germination have been tabulated in Table 4.1. The average seed germination percentage among the *neikumbalam* accessions was 37.52%. The highest seed germination percentage among the accessions was observed in BH 9 (59.72%) followed by BH 4, BH 1 and BH 13 (54.17 %, 52.33 % and 52 % respectively) which were significantly lesser than that in the check variety 'Indu' (66.00%). The least germination was recorded in BH 16 (12.33%).

4.1.2 Days to germination

Wide variation was observed among the *neikumbalam* accessions for number of days to germination. (Table 4.1). It ranged from 6.33 days (BH 8) to 16.67 days (BH 5), with a mean value of 10.65 days. Germination in the check variety 'Indu' occurred in 6.67 days which was on par with BH 8 (6.33 days) and BH 4 (6.67 days).

Table 4.1 Seed germination of *neikumbalam* accessions

Accession No	Seed germination (%)	Number of days to germination
BH 1	52.33^{c}	13.67^{bc}
BH 2	24.44^{h}	11.33^{d}
BH 3	36.00^{e}	8.67^{f}
BH 4	54.17^{c}	6.67^{gh}
BH 5	22.00^{h}	16.67^{a}
BH 6	28.56^{g}	11.33^{d}
BH 7	23.67^{h}	9.00^{ef}
BH 8	33.44^{ef}	6.33^{h}
BH 9	59.72^{b}	12.33^{cd}
BH 10	33.33^{ef}	14.67^{b}
BH 11	31.00^{fg}	9.33^{ef}
BH 12	47.50^{d}	7.67^{fgh}
BH 13	52.00^{c}	8.33^{fg}
BH 14	45.44^{d}	11.33^{d}
BH 15	44.33^{d}	12.33^{cd}
BH 16	12.33^{i}	10.67^{de}
Mean	37.52	10.65
Check	66.00^{a}	6.67^{gh}
CD (5%)	4.10	1.75

4.1.3 Vine length

Data presented in Table 4.2 gives the vine length recorded at four different stages of crop growth. The check variety 'Indu' recorded significantly highest vine length at all the growth stages compared to the *neikumbalam* accessions. Among the *neikumbalam* types, highest vine length was recorded in BH 11 at all the four growth stages.

The mean vine length of the *neikumbalam* types at the pre-flowering stage was 82.54 cm. The highest vine length among *neikumbalam* types was recorded in BH 11 (172.85 cm) followed by BH 2, BH 9, BH 7 and BH 5 (116.56 cm, 111.76 cm, 108.75 cm and 107.65 cm respectively). The least vine length at pre-flowering stage was observed in BH 1 (29.68 cm). Vine length in the check variety 'Indu' was 220.75 cm at this stage.

At the flowering stage, vine length among the accessions ranged from 39.75 cm to 212.55 cm with a mean of 105.96 cm. Vine length in 'Indu' at flowering stage was 263.25 cm. Among the *neikumbalam* types, highest vine length was recorded in BH 11 (212.55 cm) followed by BH 9, BH 5 and BH 2 (164.1 cm, 155.7 cm and 141.35 cm respectively). Vine length was the least at flowering stage in BH 1 (39.75 cm).

At the fruiting stage, vine length ranged from 48.67 cm to 245.84 cm among the *neikumbalam* accessions with a mean of 130.38 cm. In the check variety 'Indu', vine length at fruiting stage was 321.62 cm. The highest vine length was recorded in BH 11 (245.54 cm) followed by BH 9, BH 5 and BH 2, with vine lengths of 196.25 cm, 184.5 cm and 179.58 cm. The lowest vine length of 48.67 cm was recorded in BH 1.

At the harvest stage, vine length of the *neikumbalam* accessions ranged from 64.66 cm to 289.46 cm with a mean of 162.68 cm. Vine length at the harvest stage in 'Indu' was 370.5 cm. The highest vine length among the *neikumbalam* accessions at harvest stage was observed in BH 11 (289.46 cm) followed by BH 9, BH 5 and

Table 4.2 Vine length of *neikumbalam* accessions at different growth stages

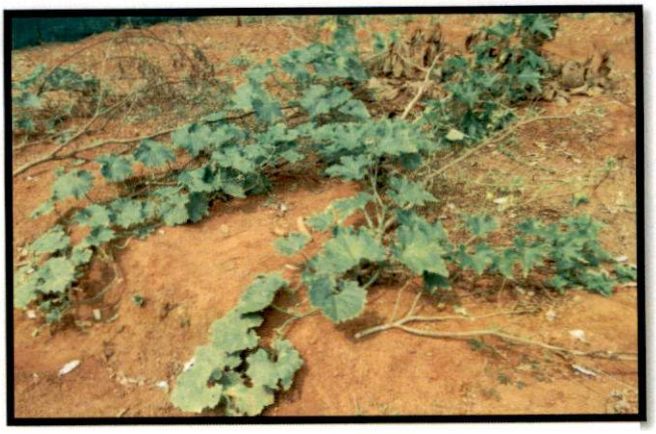
Accession No	Vine length (cm)			
	Pre-flowering stage	Flowering stage	Fruiting stage	Harvest stage
BH 1	29.68^{j}	39.75^{m}	48.67^{i}	64.66^{j}
BH 2	116.56^{c}	141.35^{cd}	179.58^{cd}	199.35^{d}
BH 3	53.55^{ghi}	68.60^{jkl}	91.50^{gh}	118.77^{hi}
BH 4	82.00^{ef}	94.60^{fghi}	104.50^{fg}	136.75^{fgh}
BH 5	107.65^{cd}	155.70^{c}	184.50^{cd}	208.65^{cd}
BH 6	67.90^{fg}	81.74^{hijk}	100.42^{fg}	128.75^{ghi}
BH 7	108.75^{c}	128.60^{de}	165.42^{d}	202.30^{cd}
BH 8	42.50^{ij}	54.83^{lm}	75.25^{h}	102.65^{i}
BH 9	111.76^{c}	164.10^{c}	196.25^{c}	229.75^{c}
BH 10	82.60^{ef}	101.45^{fgh}	129.22^{e}	161.75^{ef}
BH 11	172.85^{b}	212.55^{b}	245.84^{b}	289.46^{b}
BH 12	81.10^{ef}	115.40^{ef}	140.00^{e}	180.91^{de}
BH 13	64.30^{gh}	89.55^{ghij}	119.84^{ef}	143.50^{fgh}
BH 14	91.75^{de}	111.65^{efg}	140.42^{e}	161.40^{ef}
BH 15	56.60^{ghi}	75.40^{ijkl}	87.50^{gh}	150.85^{fg}
BH 16	51.10^{hi}	60.10^{klm}	77.17^{h}	123.30^{ghi}
Mean	82.54	105.96	130.38	162.68
Check	220.75^{a}	263.25^{a}	321.62^{a}	370.50^{a}
CD (5%)	16.40	23.35	22.17	28.12

a. Seedling stage

b. Vining

c. Pre flowering stage

d. Flowering stage



e. Fruiting stage

Plate 4.1 Different growth stages of *neikumbalam*

BH 7 (229.75 cm, 208.65 cm and 202.3 cm respectively). The lowest vine length at harvest stage was observed in BH 1 (64.66 cm). Different growth stages of the crop is depicted in Plate 4.1.

4.1.4 Number of primary branches

The data on the number of primary branches at various stages of the crop has been tabulated in Table 4.3. The number of primary branches was significantly higher in the check variety 'Indu' than the *neikumbalam* types at all four stages of the crop.

At the pre-flowering stage, significantly highest number of primary branches was observed in 'Indu' was 4.66 and it was on par with the number of primary branches recorded in the accessions BH 7 and BH 11 (4.12 and 4.02 respectively). The number of primary branches at pre flowering stage in the types BH 9, BH 5 and BH 4 (3.94, 3.76 and 3.6 respectively) was also comparable to this. The mean value among the accessions for the number of primary branches at pre flowering stage was 2.58 with values ranging from 1.15 to 4.12. The least number of primary branches at this stage was recorded in BH 8 (1.15).

At the flowering stage, number of primary branches was significantly highest in the check variety 'Indu' (7.75). Among the *neikumbalam* types, number of primary branches at flowering stage was highest in BH 11 (5.84) which was on par with BH 9 (5.42). The number of primary branches in the types BH 7 and BH 5 (5.08 and 4.88 respectively) was also comparable to this. The least number of primary branches at flowering stage was observed in BH 8 (1.4). The mean value for number of primary branches at this stage among the *neikumbalam* types was 3.36.

At fruiting stage, number of primary branches among the *neikumbalam* types ranged from 1.84 to 7.4 with a mean of 4.58. The check variety 'Indu' recorded significantly highest number of primary branches at this stage also (8.84). Among *neikumbalam* types, the highest number of primary branches at fruiting was

Table 4.3 Number of primary branches in *neikumbalam* accessions at different growth stages

Accession No.	Number of primary branches			
	Pre flowering stage	Flowering stage	Fruiting stage	Harvest stage
BH 1	2.05^{cd}	2.84^{fgh}	4.04^{ghi}	4.85^{ef}
BH 2	2.90^{bc}	3.75^{def}	4.50^{fg}	5.68^{de}
BH 3	2.00^{cd}	2.62^{fgh}	4.50^{fg}	6.20^{d}
BH 4	3.60^{ab}	4.06^{cde}	5.12^{ef}	6.24^{d}
BH 5	3.76^{ab}	4.88^{bcd}	6.30^{cd}	7.58^{b}
BH 6	2.04^{cd}	2.25^{hi}	2.75^{jk}	3.96^{fgh}
BH 7	4.12^{a}	5.08^{bc}	6.02^{de}	8.08^{b}
BH 8	1.15^{d}	1.40^{i}	1.84^{k}	3.15^{h}
BH 9	3.94^{ab}	5.42^{b}	7.15^{bc}	7.30^{bc}
BH 10	1.88^{cd}	2.65^{fgh}	3.50^{hij}	4.66^{fg}
BH 11	4.02^{a}	5.84^{b}	7.40^{b}	7.84^{b}
BH 12	1.85^{cd}	2.38^{ghi}	3.22^{ij}	4.80^{ef}
BH 13	2.12^{cd}	2.96^{efgh}	4.20^{fgh}	4.69^{fg}
BH 14	2.86^{bc}	3.50^{efg}	6.10^{d}	6.44^{cd}
BH 15	1.42^{d}	1.92^{hi}	3.37^{hij}	4.75^{efg}
BH 16	1.56^{d}	2.25^{hi}	3.24^{ij}	3.84^{gh}
Mean	2.58	3.36	4.58	5.63
Check	4.66^{a}	7.75^{a}	8.84^{a}	9.06^{a}
CD (5%)	1.12	1.12	0.93	0.95

recorded in BH 11 (7.4) and it was on par with BH 9 (7.15). The least number of primary branches was recorded in BH 8 (1.84).

At the harvest stage, number of primary branches in the check variety 'Indu' (9.06) was significantly higher than the *neikumbalam* types. Number of primary branches among the *neikumbalam* types ranged from 3.15 to 8.08 with a mean of 5.63. The type BH 7 recorded highest number of primary branches among them (8.08) and the types BH 11, BH 5 and BH 9, with values of 7.84, 7.58 and 7.3 were also comparable to this. The least number of primary branches at harvest stage was observed in the type BH 8 (3.15).

4.1.5 Number of leaves

The data on the number of leaves per plant at different growth stages have been recorded in Table 4.4. Number of leaves was significantly highest in the check variety 'Indu' during the first three growth stages, *viz.* pre-flowering, flowering and fruiting stages and highest in the *neikumbalam* type BH 11 at the harvest stage.

At the pre-flowering stage, the check variety 'Indu' recorded 84.34 leaves. Highest number of leaves among *neikumbalam* types was observed in BH 11 (62.6) and this was on par with BH 5 (52.8). The least number of leaves was recorded in BH 8 (22.25). The mean value for number of leaves at pre- flowering stage among *neikumbalam* accessions was 36.84.

At flowering stage, the mean value for number of leaves among *neikumbalam* types was 56.96 with lowest number of leaves recorded in BH 1 (31.1). Number of leaves in 'Indu' at flowering stage was 113.66, and the *neikumbalam* type BH 11 (105.95) was comparable to 'Indu' for this character followed by BH 2 (93.65).

The number of leaves at fruiting stage among the *neikumbalam* types ranged from 39.66 to 129.83 with a mean of 74.55. The highest number of leaves was recorded in *neikumbalam* type BH 11 (129.83) and it was on par with the check

Table 4.4 Number of leaves and leaf area of *neikumbalam* accessions at different growth stages

Accession No	Number of leaves				Leaf area (cm^2)
	Pre flowering stage	Flowering stage	Fruiting stage	Harvest stage	
BH 1	23.45^{f}	31.10^{h}	39.66^{g}	51.75^{k}	106.08^{def}
BH 2	50.80^{c}	93.65^{b}	110.08^{b}	141.00^{bc}	110.10^{cde}
BH 3	24.75^{f}	42.40^{fgh}	58.88^{ef}	77.45^{ij}	146.78^{abc}
BH 4	28.30^{f}	43.66^{fgh}	61.64^{def}	80.82^{ij}	100.97^{def}
BH 5	52.80^{bc}	77.84^{c}	102.62^{bc}	116.90^{de}	93.44^{def}
BH 6	31.05^{ef}	47.95^{fg}	70.08^{de}	90.75^{fghi}	125.40^{abcd}
BH 7	40.80^{de}	54.12^{ef}	70.50^{de}	86.66^{hi}	126.31^{abcd}
BH 8	22.25^{f}	36.85^{gh}	49.25^{fg}	67.45^{jk}	67.16^{f}
BH 9	48.84^{cd}	69.25^{cd}	89.34^{c}	102.70^{efg}	102.54^{def}
BH 10	31.16^{ef}	44.11^{fg}	60.62^{ef}	86.11^{hi}	110.12^{cde}
BH 11	62.60^{b}	105.95^{ab}	129.83^{a}	157.12^{a}	158.80^{a}
BH 12	44.12^{cd}	61.90^{de}	75.25^{d}	104.50^{ef}	119.47^{bcd}
BH 13	31.16^{ef}	48.62^{fg}	70.24^{de}	97.95^{fgh}	74.59^{ef}
BH 14	44.84^{cd}	74.12^{cd}	96.92^{bc}	125.45^{cd}	120.73^{abcd}
BH 15	29.75^{f}	43.65^{fgh}	58.58^{ef}	88.00^{ghi}	96.16^{def}
BH 16	22.75^{f}	36.10^{gh}	49.34^{fg}	76.25^{ij}	79.15^{ef}
Mean	36.84	56.96	74.55	96.93	108.61
Check	84.34^{a}	113.66^{a}	136.38^{a}	156.80^{ab}	154.66^{ab}
CD (5%)	9.86	12.78	13.88	15.83	39.03

variety 'Indu' (136.38) followed by BH 2 (110.08), BH 5 (102.62) and BH 14 (96.92). The least number of leaves at flowering was observed in BH 1 (39.66).

The number of leaves at harvest stage was highest in BH 11 (157.12). This was comparable to the check variety 'Indu' (156.8) followed by the *neikumbalam* type BH 2 (141). The least number of leaves at harvest stage was observed in BH 1 (51.75). The mean value among the *neikumbalam* types for this character was 96.93.

4.1.6 Leaf area

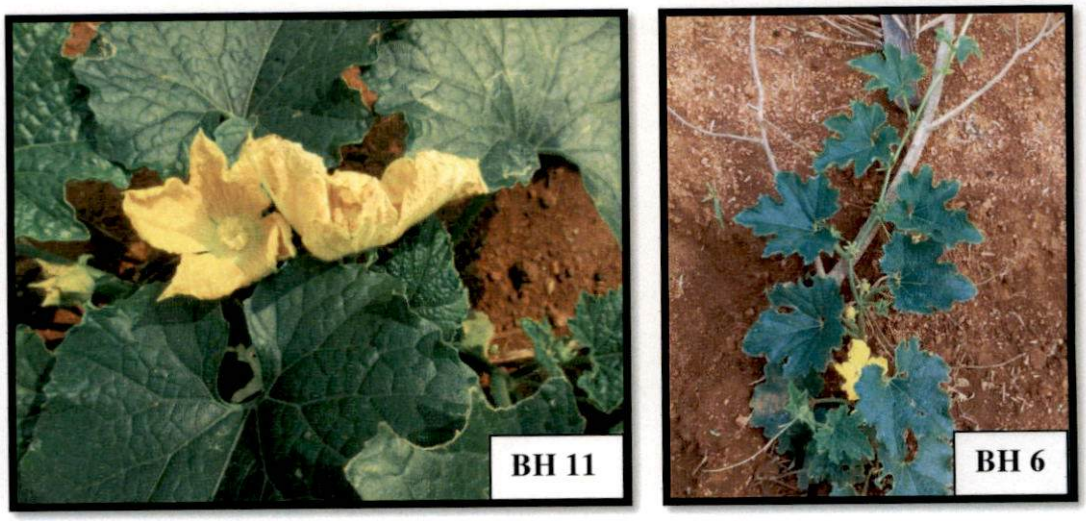
The data on leaf area at flowering stage for the *neikumbalam* accessions and check variety 'Indu' have been presented in Table 4.4. The highest leaf area was recorded in BH 11 (158.8 cm^2) and it was comparable to the check variety 'Indu' (154.66 cm^2). Leaf area in the types BH 3, BH 7, BH 6 and BH 14 (146.78 cm^2, 126.31 cm^2, 125.4 cm^2 and 120.73 cm^2 respectively) were also comparable to this. Leaves of the type BH 8 had the least leaf area (67.16 cm^2). The mean value of leaf area for these *neikumbalam* accessions was 108.61 cm^2.

4.1.7 Days to first male flower

The data on various flowering characters have been tabulated in Table 4.5. Significantly lowest number of days to opening of first male flower was recorded in BH 16 (59 days) and it was on par with the number of days to first male flower recorded in BH 14, BH 13 and BH 15 (61.75 days, 62.05 days and 62.25 days respectively). The check variety 'Indu' took 77.42 days for opening of first male flower. The highest number of days to opening of first male flower was observed in BH 7 (115 days). The mean number of days to first male flower among the *neikumbalam* accessions was 83.7. Plate 4.2 presents the flowering in *neikumbalam* accessions.

Table 4.5 Flowering characters of *neikumbalam* accessions

Accession No.	Days to first male flower	Days to first female flower	Node to first male flower	Node to first female flower	Number of male flowers	Number of female flowers	Sex ratio
BH 1	79.00^{f}	86.50^{f}	10.00^{efgh}	10.50^{ef}	18.75^{bcdef}	3.75^{bcd}	5.26^{def}
BH 2	87.50^{de}	100.75^{de}	11.75^{defg}	14.00^{cde}	21.50^{bcde}	6.00^{a}	3.50^{f}
BH 3	93.00^{bcd}	107.75^{bcde}	10.00^{efgh}	13.25^{cde}	19.50^{bcdef}	3.75^{bcd}	5.50^{def}
BH 4	98.50^{b}	108.50^{bcd}	12.50^{cdef}	22.25^{ab}	24.00^{bcd}	3.75^{bcd}	6.34^{bcd}
BH 5	97.50^{b}	112.50^{bc}	17.25^{ab}	17.75^{bcd}	23.00^{bcd}	3.75^{bcd}	6.40^{bcd}
BH 6	81.00^{ef}	86.75^{f}	8.00^{gh}	11.75^{de}	25.00^{bc}	5.00^{ab}	4.70^{def}
BH 7	115.00^{a}	125.92^{a}	10.25^{efgh}	17.34^{bcd}	25.66^{b}	4.66^{abc}	5.28^{def}
BH 8	94.08^{bc}	106.50^{cde}	11.92^{def}	17.50^{bcd}	16.66^{cdef}	3.25^{bcd}	5.75^{cde}
BH 9	89.50^{cd}	116.00^{b}	16.00^{abc}	19.25^{abc}	19.75^{bcdef}	2.75^{d}	7.91^{ab}
BH 10	92.50^{bcd}	104.75^{cde}	14.75^{abcd}	15.75^{cde}	16.25^{def}	2.25^{d}	7.64^{abc}
BH 11	88.00^{cd}	99.25^{e}	18.00^{a}	22.25^{ab}	25.75^{b}	4.75^{abc}	5.49^{def}
BH 12	78.62^{f}	86.33^{f}	8.75^{fgh}	13.00^{cde}	20.24^{bcde}	3.00^{cd}	6.00^{bcde}
BH 13	62.05^{g}	55.62^{g}	11.25^{defg}	4.75^{f}	23.95^{bcd}	3.25^{bcd}	7.58^{abc}
BH 14	61.75^{g}	60.75^{g}	13.75^{bcde}	12.50^{de}	14.00^{ef}	2.50^{d}	6.38^{bcd}
BH 15	62.25^{g}	61.00^{g}	15.00^{abcd}	13.50^{cde}	22.48^{bcde}	2.75^{d}	8.52^{a}
BH 16	59.00^{g}	58.75^{g}	7.00^{h}	15.75^{cde}	11.50^{f}	3.00^{cd}	4.02^{ef}
Mean	83.70	92.35	12.26	15.04	20.50	3.64	6.01
Check	77.42^{f}	87.17^{f}	11.88^{def}	24.79^{a}	42.46^{a}	4.79^{abc}	9.37^{a}
CD (5%)	6.55	8.56	3.76	6.34	8.641	1.86	2.04



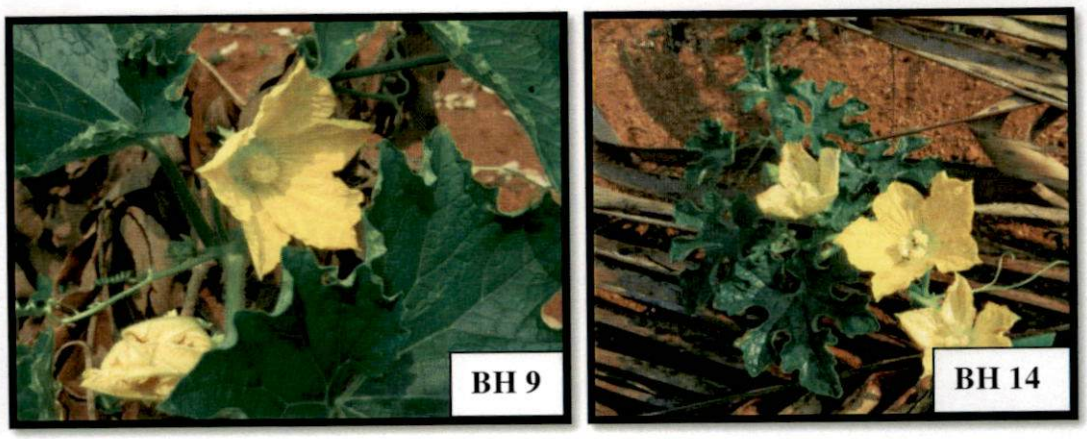


Plate 4.2 Flowering in *neikumbalam* accessions

4.1.8 Days to first female flower

Days to opening of first female flower was significantly lowest in BH 13 (55.62 days) which was on par with the number of days to first female flower in the types BH 16, BH 14 and BH 15 (58.75 days, 60.75 days and 61 days respectively). The highest number of days to first female flower was observed in BH 7 (125.92 days). The check 'Indu' recorded 87.17 days for first female flower emergence. The mean value for this character among the *neikumbalam* accessions was 92.35. It was also observed that opening of first female flower took place earlier than first male flower in the types BH 13, BH 14, BH 15 and BH 16, whereas in all other accessions, male flowers opened earlier.

4.1.9 Nodes to first male flower

The *neikumbalam* type BH 16 recorded significantly lowest number of nodes to first male flower (7 nodes). This was comparable to the number of nodes to first male flower observed in BH 6 and BH 12 (8 and 8.75 nodes respectively) followed by BH 3, BH 7 and BH 1 (10, 10.25 and 10.5 nodes respectively). The highest number of nodes to first male flower was recorded in BH 11 (18 nodes). A mean value of 12.26 was recorded for this character among the *neikumbalam* types. The node number to first male flower in the check variety 'Indu' was 11.88.

4.1.10 Nodes to first female flower

Number of nodes to first female flower had a mean value of 15.04 for the *neikumbalam* types. Significantly lowest number of nodes to first female flower was recorded in BH 13 (4.75 nodes). The check variety 'Indu' recorded significantly highest number of nodes to first female flower than all *neikumbalam* types (24.79 nodes) and it was comparable to the types BH 4 and BH 11 (22.25 nodes). Also, in the types BH 13, BH 14 and BH 15, female flowers were produced on lower nodes than male flowers.

4.1.11 Number of male flowers

The number of male flowers was significantly highest in the check variety 'Indu' (42.46). Highest number of male flowers among *neikumbalam* types was observed in BH 11 (25.75) which was on par with BH 7 (25.66). Number of male flowers in BH 6, BH 4, BH 13, BH 5, BH 15 and BH 2 (25, 24, 23.95, 23, 22.48 and 21.5 male flowers, respectively) was also comparable to this. The least number of male flowers was observed in BH 16 (11.5). The mean number of male flowers among the *neikumbalam* accessions was 20.50.

4.1.12 Number of female flowers

The mean number of female flowers among *neikumbalam* types was 3.64. Significantly highest number of female flowers was recorded in BH 2 (6). Also, number of female flowers in BH 6 (5), check variety 'Indu' (4.79), BH 11 (4.75) and BH 7 (4.66 female flowers) was comparable to this. The lowest number of female flowers was observed in BH 10 (2.25).

4.1.13 Sex ratio

Sex ratio in the check variety 'Indu' was found to be significantly higher (9.37) and it was on par with the *neikumbalam* type BH 15 (8.52). Sex ratio in the types BH 9, BH 10 and BH 13 (7.91, 7.64 and 7.58) were also comparable to this. The mean value for this character among the *neikumbalam* types was 6.01. The lowest sex ratio of 3.5 was recorded in BH 2.

4.1.14 Fruit set per cent

The data on the yield and yield parameters of *neikumbalam* types and check variety 'Indu' have been tabulated in Table 4.6. Fruit set per cent showed wide variation among the accessions. The mean value for fruit set per cent among

Table 4.6 Yield and yield parameters of *neikumbalam* accessions

Accession No.	Fruit set per cent	Number of fruits per plant	Fruit yield per plant (kg)	Days to fruit maturity	Crop duration
BH 1	22.50 (28.28)^{cd}	1.00^{f}	0.90^{efg}	38.00^{cd}	119.66^{g}
BH 2	39.16 (38.70)^{bc}	2.25^{abc}	1.90^{c}	40.04^{bc}	141.92^{bcd}
BH 3	46.43 (42.95)^{bc}	1.75^{cde}	1.32^{cde}	38.50^{cd}	143.92^{bc}
BH 4	58.34 (49.87)^{ab}	1.75^{cde}	1.39^{cde}	42.50^{ab}	139.30^{cde}
BH 5	46.66 (43.01)^{bc}	1.75^{cde}	1.32^{cde}	36.00^{de}	122.75^{g}
BH 6	35.18 (36.33)^{bc}	1.84^{cde}	1.55^{cd}	42.00^{b}	135.75^{ef}
BH 7	55.87 (48.38)^{ab}	2.84^{a}	3.48^{b}	42.06^{b}	144.50^{b}
BH 8	34.99 (36.26)^{bc}	1.25^{ef}	1.02^{defg}	45.12^{a}	134.00^{f}
BH 9	41.66 (40.13)^{bc}	1.25^{ef}	1.18^{def}	38.25^{cd}	153.00^{a}
BH 10	41.66 (40.13)^{bc}	1.00^{f}	0.68^{fg}	33.50^{e}	145.85^{b}
BH 11	41.25 (39.88)^{bc}	1.75^{cde}	1.46^{cde}	41.62^{b}	152.16^{a}
BH 12	43.75 (41.38)^{bc}	1.42^{def}	0.49^{gh}	41.84^{b}	137.88^{def}
BH 13	0.00 (0.49)^{d}	0.00^{g}	0.00^{h}	0.00^{f}	104.46^{hi}
BH 14	75.00 (67.25)^{a}	2.00^{bcd}	1.34^{cde}	35.00^{e}	106.84^{hi}
BH 15	36.66 (37.25)^{bc}	1.50^{def}	0.90^{efg}	33.75^{e}	108.00^{h}
BH 16	33.33 (35.26)^{bc}	1.00^{f}	0.46^{gh}	34.00^{e}	102.66^{i}
Mean	40.78	1.52	1.21	36.39	130.79
Check	51.92 (46.11)^{ab}	2.54^{ab}	6.13^{a}	38.23^{cd}	136.88^{ef}
CD (5%)	19.42	0.65	0.62	2.91	4.67

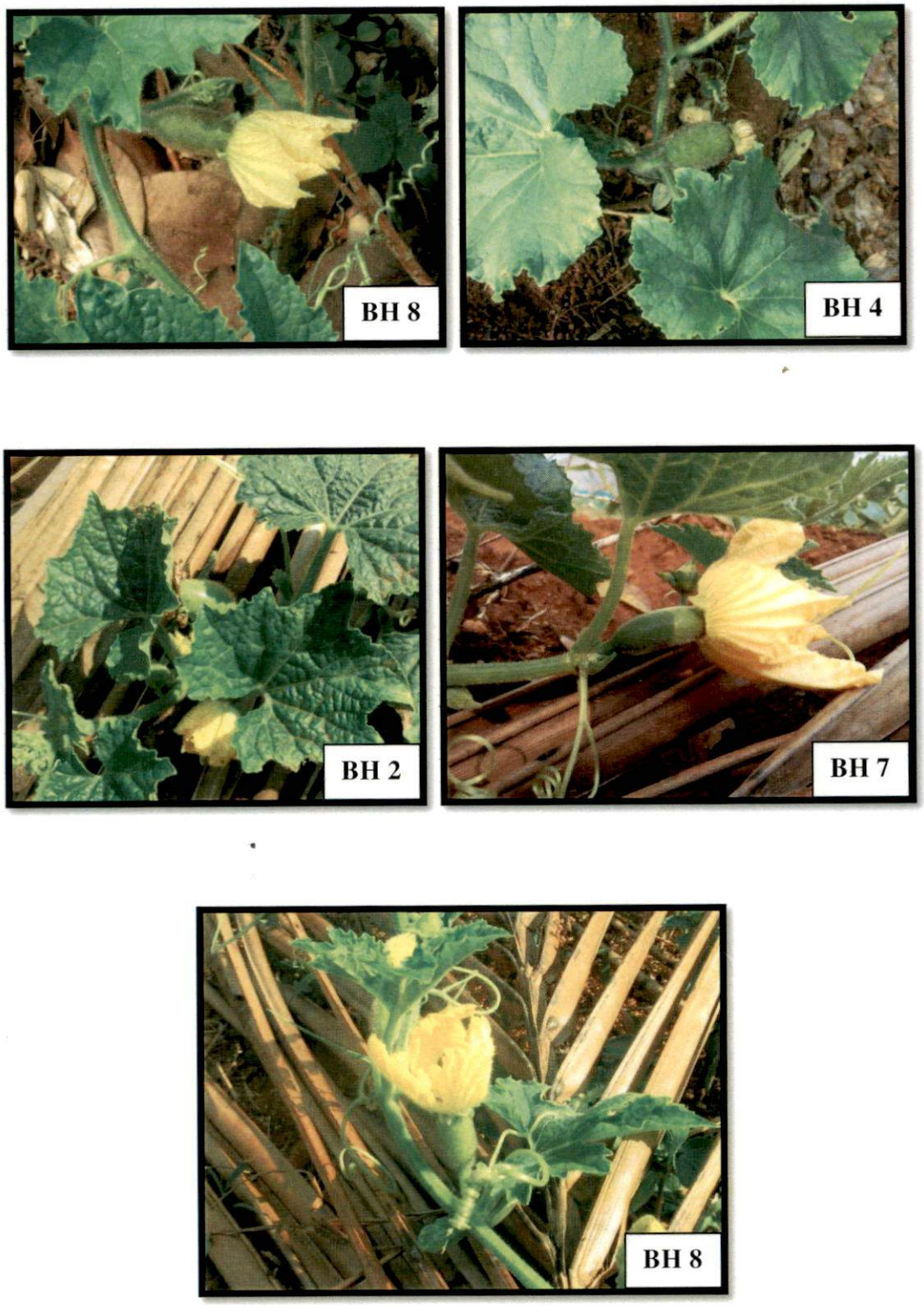


Plate 4.3 Fruit set in *neikumbalam* accessions

the accessions was 40.78 %. The type BH 14 recorded significantly higher fruit set per cent (75 %) than all other *neikumbalam* types and the check variety 'Indu'. Fruit set per cent in the types BH 4, BH 7 and the check variety 'Indu' (58.34 %, 55.87 % and 51.92 %) were also comparable to this. The least value for fruit set per cent was recorded in BH 1 (22.5 %). No fruit set was observed in BH 13. Fruit set in *neikumbalam* accessions is shown in Plate 4.3.

4.1.15 Fruits per plant

The number of fruits per plant was significantly highest in the type BH 7 (2.84 fruits per plant). Fruits per plant in the check variety 'Indu' (2.54) and BH 2 (2.15) were comparable to this. The least number of fruits per plant were recorded in BH 1, BH 10 and BH 16 (one fruit per plant each). The mean value for number of fruits per plant among the *neikumbalam* accessions was 1.52.

4.1.16 Fruit yield

Fruit yield per plant for *neikumbalam* accessions ranged from 0.46 kg to 3.48 kg with a mean of 1.21 kg per plant. The check variety 'Indu' recorded a significantly higher yield of 6.13 kg per plant than all *neikumbalam* types. Among the *neikumbalam* types, BH 7 recorded the highest fruit yield (3.48 kg) and was significantly higher than other accessions. The lowest fruit yield was recorded in the types BH 16 (0.46 kg per plant) and BH 12 (0.49 kg per plant).

4.1.17 Days to maturity

Significantly lowest number of days to fruit maturity was recorded in BH 10 (33.5 days) which was on par with BH 15, BH 16 and BH 14 (33.75, 34 and 35 days respectively). Days to fruit maturity was significantly highest in the type BH 8 (45.12 days) followed by BH 4 (42.5 days). The mean value for days to fruit

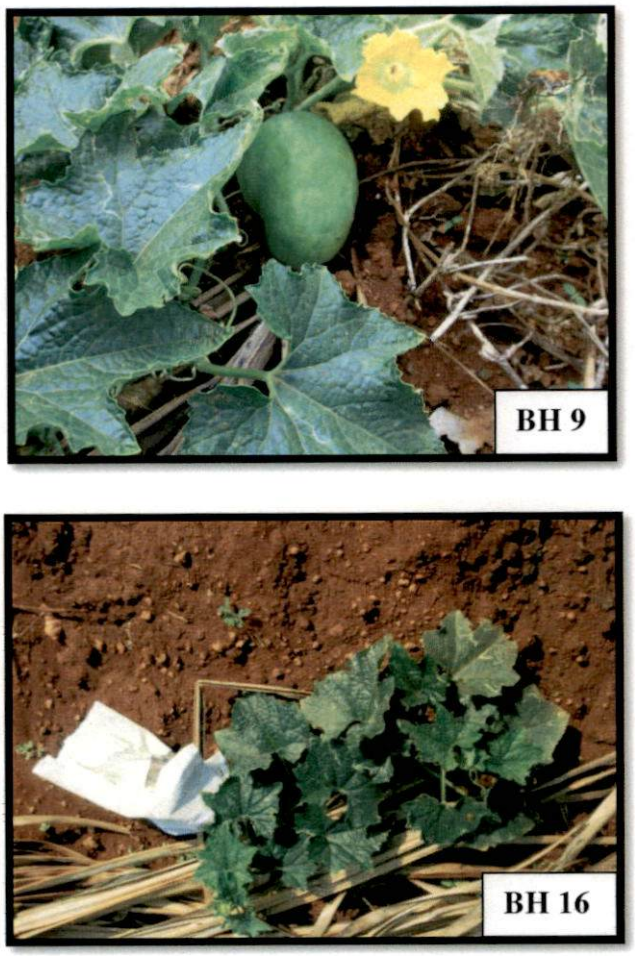


Plate 4.4 Fruit development in *neikumbalam* accessions

Plate 4.5 Fruit development in check variety 'Indu'

maturity among the *neikumbalam* accessions was 36.39 days. The check variety 'Indu' took 38.23 days for the same. Fruit development in *neikumbalam* accessions and the check variety 'Indu' are shown in Plate 4.4 and Plate 4.5 respectively.

4.1.18 Crop duration

The mean value for crop duration among the *neikumbalam* types was 130.79 days. Crop duration was significantly lowest in the type BH 16 (102.66 days). This was comparable to the crop duration in BH 13 and BH 14 (104.46 and 106.84 days respectively). The highest number of days for crop duration was observed in BH 9 (153 days) and it was comparable to BH 11 (152.16 days). Crop duration recorded in the check variety 'Indu' was 136.88 days.

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4.1.19 Disease/ pest incidence

Incidence of insect pests like red pumpkin beetle and serpentine leaf miner was observed. Some plants were affected by mosaic disease.

A major mammalian pest that affected the crop yield was wild boar. Wild boar attack resulted in the loss of fruits in the *neikumbalam* accessions BH 1, BH 5, BH 10, BH 14, BH 15 and BH 16.

4.2 Fruit characters

Results of the following qualitative and quantitative fruit characters are furnished here.

4.2.1 Shape

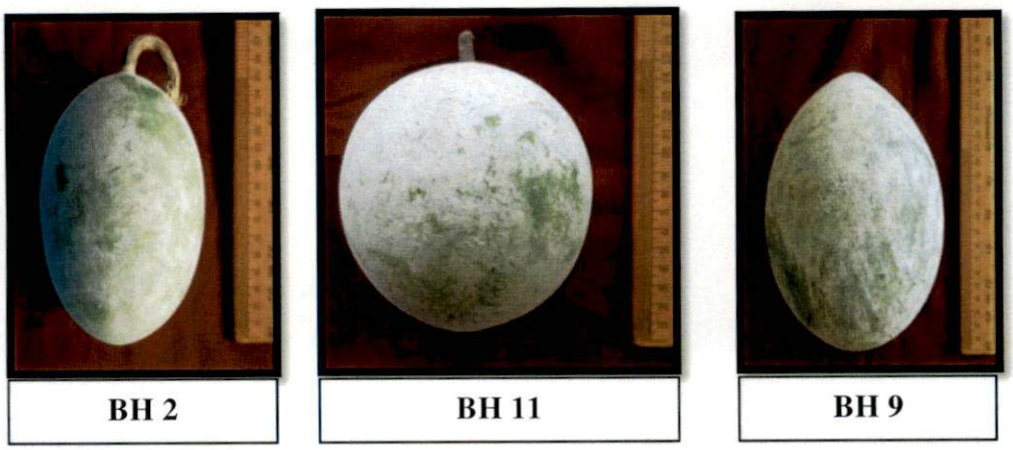
The data on various qualitative fruit characters have been tabulated in Table 4.7. Variability was observed in fruit shape. Oblong fruits were observed in seven accessions (BH 1, BH 2, BH 3, BH 6, BH 7, BH 8 and BH 12), spherical fruits in

67

Table 4.7 Qualitative fruit characters of *neikumbalam* accessions

Accession No.	Fruit shape	Waxiness	Hairiness	Rind colour	Keeping quality
BH 1	Oblong	Medium	Low	Dark green	8 weeks
BH 2	Oblong	Medium	High	Bright green	9 weeks
BH 3	Oblong	Medium	Low	Dark green	6 weeks
BH 4	Spherical	High	Medium	Yellowish green	11 weeks
BH 5	Spherical	High	Medium	Light green	11 weeks
BH 6	Oblong	Low	Low	Dark green	7 weeks
BH 7	Oblong	High	Low	Dark green	7 weeks
BH 8	Oblong	Medium	Low	Dark green	7 weeks
BH 9	Conical	Medium	Low	Light green	6 weeks
BH 10	Conical	Low	Low	Light green	6 weeks
BH 11	Spherical	High	Low	Bright green	9 weeks
BH 12	Oblong	Medium	High	Light green	9 weeks
Check	Oblong	Medium	Low	Light green	7 weeks

Plate 4.6 Relative fruit size of *neikumbalam* and 'Indu'



a. Oblong **b. Spherical** **c. Conical**

Plate 4.7 Variability in shape of *neikumbalam* fruits

three accessions (BH 4, BH 5 and BH 11) and conical fruits in two accessions (BH 9 and BH 10). The check variety 'Indu' produced oblong fruits. Plates 4.6 and 4.7 depict the fruit size and fruit shape observed in neikumbalam types and 'Indu'.

4.2.2 Waxiness

The intensity of waxiness varied among the accessions (Plate 4.8). Waxiness over the fruit surface was found to be low in the accessions BH 6 and BH 10. It was of medium intensity in majority of the accessions (BH 1, BH 2, BH 3, BH 8, BH 9 and BH 12) and in the check variety 'Indu'. Waxiness was high in the accessions BH 4, BH 5, BH 7 and BH 11.

4.2.3 Hairiness

Hairiness was low in the check variety 'Indu' and majority of the *neikumbalam* accessions (BH 1, BH 3, BH 6, BH 7, BH 8, BH 9, BH 10 and BH 11). It was medium in two accessions (BH 4 and BH 5) and hairiness was high in two other accessions (BH 2 and BH 12).

4.2.4 Rind colour

It was observed that five accessions had a dark green rind colour (BH 1, BH 3, BH 6, BH 7 and BH 8), two accessions with bright green rind colour (BH 2 and BH 11), one accession with yellowish green rind colour (BH 4) and four accessions (BH 5, BH 9, BH 10 and BH 12) and the check variety 'Indu' had a light green rind colour.

4.2.5 Keeping quality

The keeping quality of fruits ranged from 6 weeks (BH 3, BH 9 and BH 10) to 11 weeks (BH 4 and BH 5). The check variety 'Indu' had a keeping quality of 7 weeks.

4.2.6 Length of fruit

Data on various quantitative fruit characters have been tabulated in Table 4.8. Fruit length showed considerable variation among the accessions. It varied from 9.8 cm to 24 cm with a mean of 14.98 cm. The check variety 'Indu' recorded significantly highest fruit length than the *neikumbalam* accessions (29.20 cm). The highest fruit length among the *neikumbalam* types was recorded in BH 1 (24 cm) and it was on par with BH 7 having a fruit length of 23 cm. The lowest fruit length was observed in BH 12 (9.8 cm).

4.2.7 Diameter of fruit

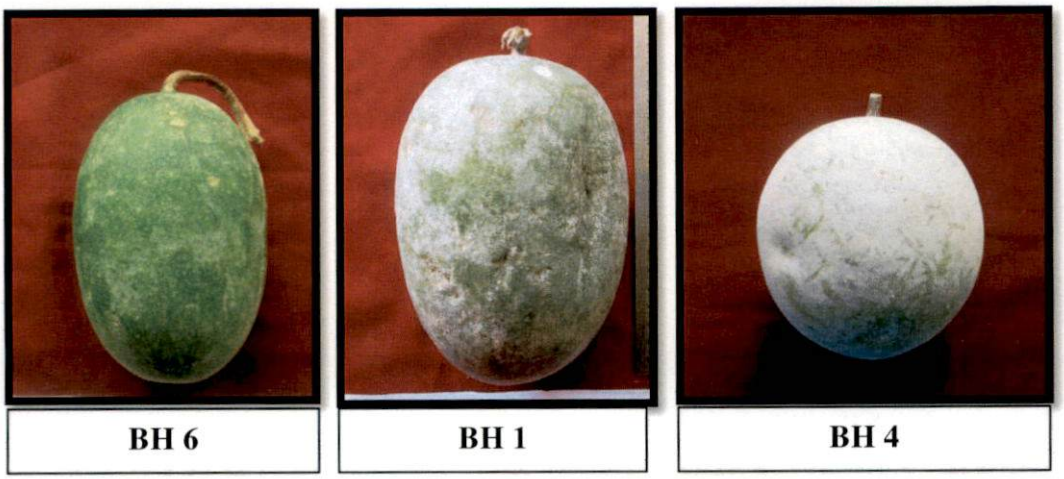
The mean value for fruit diameter among *neikumbalam* accessions was 11.14 cm. Fruit diameter in the check variety 'Indu' (14.8 cm) was significantly higher than all *neikumbalam* accessions. Highest fruit diameter among the *neikumbalam* types was recorded in BH 5 (13.6 cm) and it was comparable to the fruit diameter in BH 7 and BH 11 (13.1 cm, 12.9 cm and 12.8 cm respectively). Fruit diameter was lowest in BH 12 (7.9 cm).

4.2.8 Weight of fruit

Fruit weight varied significantly among the accessions. Average fruit weight was significantly higher in the check variety 'Indu' (2380 g). Among the *neikumbalam* accessions, fruit weight ranged from 349 g to 1250 g with a mean

Table 4.8 Quantitative fruit characters of *neikumbalam* accessions

Accession No.	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Rind thickness (mm)	Flesh thickness (mm)
BH 1	24.00^{b}	11.60^{de}	962.00^{cd}	2.00^{cd}	16.33^{fg}
BH 2	14.70^{cdef}	9.40^{f}	855.00^{cde}	2.00^{cd}	15.67^{g}
BH 3	13.30^{def}	9.50^{f}	725.00^{de}	2.67^{b}	17.00^{efg}
BH 4	12.70^{fg}	12.20^{cde}	798.00^{cde}	1.33^{e}	17.67^{efg}
BH 5	13.10^{efg}	13.60^{b}	760.00^{cde}	2.00^{cd}	19.00^{de}
BH 6	15.50^{cd}	12.40^{cd}	883.00^{cde}	2.00^{cd}	21.33^{bc}
BH 7	23.00^{b}	13.10^{bc}	1250.00^{b}	2.33^{bc}	23.33^{b}
BH 8	11.00^{gh}	8.30^{g}	783.00^{cde}	2.00^{cd}	15.67^{g}
BH 9	16.80^{c}	11.30^{e}	971.00^{c}	2.00^{cd}	18.33^{ef}
BH 10	12.60^{fg}	9.80^{f}	672.00^{e}	1.67^{de}	18.67^{de}
BH 11	13.10^{efg}	12.80^{bc}	832.00^{cde}	2.00^{cd}	19.00^{de}
BH 12	9.80^{h}	7.90^{g}	349.00^{f}	2.33^{bc}	12.00^{h}
Mean	14.98	11.14	811.85	2.02	18.05
Check	29.20^{a}	14.80^{a}	2380.00^{a}	3.33^{a}	32.67^{a}
CD (5%)	2.29	1.03	239.94	0.63	2.17



a. Low b. Medium c. High

Plate 4.8 Variability in waxiness over fruit surface

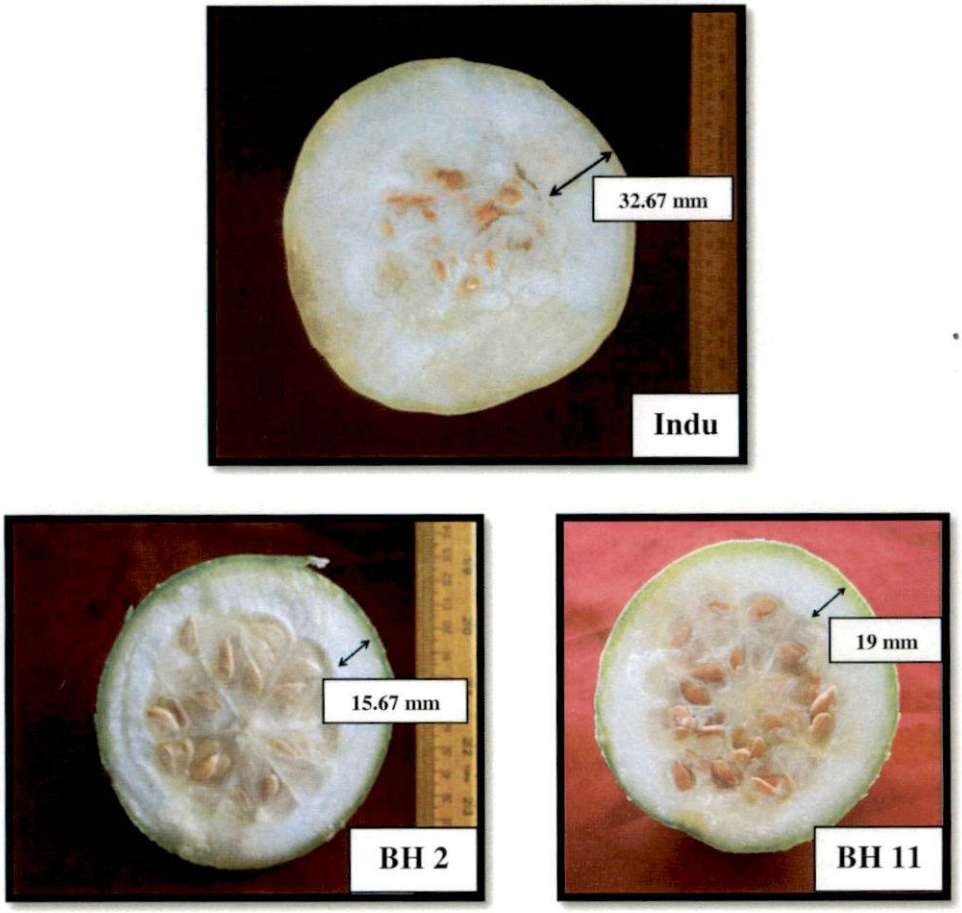


Plate 4.9 Flesh thickness in *neikumbalam* accessions and 'Indu'

value of 811.85g. The highest fruit weight among *neikumbalam* types was recorded in BH 7 (1250 g) and lowest fruit weight in BH 12 (349 g).

4.2.9 Rind thickness

The mean value for rind thickness among the *neikumbalam* accessions was 2.02 mm. Rind thickness was significantly higher in the check variety 'Indu' (3.33 mm) than all *neikumbalam* accessions. Among the *neikumbalam* types, rind thickness was highest in BH 3 (2.67 mm) which was comparable to BH 7 and BH 12 (2.33 mm). Rind thickness was found to be the lowest in BH 4 (1.33 mm).

4.2.10 Flesh thickness

Flesh thickness in the check variety 'Indu' (32.67 mm) was significantly higher than all *neikumbalam* accessions as shown in Plate 4.9. Flesh thickness was least in BH 12 (12 mm). It was highest in BH 7 (23.33 mm) which was comparable to BH 6 (21.33 mm). The mean value for flesh thickness among the *neikumbalam* types was 18.05 mm.

4.3 Seed characters

Various seed characters were recorded after extraction of seed from the fruits. Data on these seed characters are tabulated in Table 4.9.

4.3.1 Number of seeds

The *neikumbalam* type BH 7 recorded significantly highest number of seeds per fruit (739) than all other accessions and check variety 'Indu'. This was comparable to BH 6 with 690 seeds per fruit. The mean value for number of seeds per fruit among the *neikumbalam* accessions was 498.08. Number of seeds in the fruits of the check variety 'Indu' was 523. The lowest number of seeds was recorded in BH 11 (252 seeds).

Table 4.9 Seed characters of *neikumbalam* accessions

Accession No.	Number of seeds	Seed length (mm)	Seed breadth (mm)	Weight of seed coat (mg)	Weight of kernel (mg)	Hundred seed weight-fresh (g)	Hundred seed weight-dry (g)	Seed viability (%)	Kernel oil (%)
BH 1	559^{c}	10.83^{bcd}	5.67^{efg}	19.21^{f}	15.98^{gh}	3.94^{hi}	3.52^{g}	99^{ab}	0.98^{ab}
BH 2	419^{fgh}	11.50^{ab}	6.17^{cde}	22.24^{e}	17.11^{f}	4.30^{efg}	3.93^{ef}	97^{ab}	0.48^{c}
BH 3	655^{b}	10.83^{bcd}	4.83^{ij}	18.79^{f}	15.79^{h}	3.61^{i}	3.42^{g}	47^{c}	1.02^{ab}
BH 4	475^{defg}	10.17^{de}	5.00^{hij}	24.36^{d}	20.39^{cd}	4.81^{d}	4.46^{d}	97^{ab}	0.52^{c}
BH 5	386^{h}	10.00^{e}	6.50^{abc}	19.01^{f}	15.78^{h}	4.18^{gh}	3.51^{g}	98^{ab}	1.03^{ab}
BH 6	690^{ab}	11.83^{a}	5.83^{def}	21.65^{e}	16.91^{fg}	4.25^{fgh}	3.75^{f}	98^{ab}	1.07^{a}
BH 7	739^{a}	11.33^{abc}	7.00^{a}	32.18^{b}	26.78^{b}	6.02^{b}	5.84^{b}	97^{ab}	1.03^{ab}
BH 8	504^{cde}	10.83^{bcd}	6.33^{bcd}	24.34^{d}	20.15^{d}	4.55^{def}	4.48^{d}	96^{b}	0.95^{b}
BH 9	402^{gh}	10.67^{cde}	5.50^{fgh}	27.62^{c}	21.20^{c}	5.20^{c}	4.83^{c}	98^{ab}	1.03^{ab}
BH 10	435^{efgh}	11.50^{ab}	4.50^{j}	23.61^{d}	18.88^{e}	4.58^{def}	4.15^{e}	97^{ab}	0.99^{ab}
BH 11	252^{i}	9.17^{f}	5.17^{ghi}	24.64^{d}	18.98^{e}	4.61^{de}	4.39^{d}	96^{b}	1.02^{ab}
BH 12	462^{defgh}	10.83^{bcd}	6.00^{cdef}	17.96^{f}	16.06^{gh}	4.01^{gh}	3.34^{g}	99^{ab}	0.97^{ab}
Mean	498.08	10.81	5.72	22.91	18.65	4.53	4.17	93.74	0.90
Check	523^{cd}	12.00^{a}	6.83^{ab}	36.96^{a}	31.62^{a}	7.23^{a}	6.67^{a}	96^{b}	0.98^{ab}
CD (5%)	79.89	0.74	0.61	1.26	0.98	0.35	0.22	3.318	0.12

4.3.2 Seed size

Seeds of *neikumbalam* were small compared to normal ash gourd seeds. Seed length in the check variety 'Indu' (12 mm) was on par with BH 6 (11.83 mm) and was significantly higher than other *neikumbalam* types. Also, seed length in the types BH 2, BH 10 and BH7 (11.5 mm, 11.5 mm and 11.33 mm) were comparable to this. The least seed length was recorded in BH 11 (9.17 mm). The mean value for this character among the *neikumbalam* accessions was 10.81 mm.

Seed breadth among the accessions ranged from 4.50 mm to 7 mm with a mean of 5.72 mm. Significantly highest seed breadth was recorded in BH 7 (7 mm) and it was comparable to the seed breadth in the check variety 'Indu' (6.83 mm) and the *neikumbalam* type BH 5 (6.5 mm). Seed breadth was found to be lowest in BH 10 (4.5 mm) and it was comparable to BH 3 (4.93 mm).

4.3.3 Weight of seed coat

The mean value for weight of seed coat among the *neikumbalam* accessions was 22.91 mg. Seed coat weight in the check variety 'Indu' (36.96 mg) was significantly higher than *neikumbalam* types. Among the accessions, the highest value for weight of seed coat was recorded in BH 7 (32.18 mg) followed by BH 9 (27.62 mg). Seed coat weight was the lowest in BH 12 (17.96 mg) which was on par with BH 3, BH 5 and BH 1 (18.79 mg, 19.01 mg and 19.21 mg respectively).

4.3.4 Weight of kernel

Weight of seed kernel in the check variety 'Indu' (31.62 mg) was significantly highest compared to *neikumbalam* accessions. The mean value of weight of seed kernel among *neikumbalam* accessions was 18.65 mg. Among them, seed kernel weight was highest in BH 7 (26.78 mg) followed by BH 9 (21.2 mg). Weight of seed kernel was least in BH 5 (15.78 mg) and it was on par with BH 3 (15.79 mg). Seed kernel weight in BH 1 (15.98 mg) and BH 12 (16.06 mg) were also comparable to this.

4.3.5 Hundred seed weight (fresh)

The hundred seed weight (fresh) among the *neikumbalam* accessions had a mean value of 4.53 g. The hundred seed weight of freshly extracted seeds was found to be significantly highest in the check variety 'Indu' (7.23 g). Among the accessions, hundred seed weight (fresh) was highest in BH 7 (6.02 g) followed by BH 9 (5.2 g). The least value for hundred seed weight (fresh) was recorded in BH 3 (3.61) and was comparable to BH 1 (3.94 g).

4.3.6 Hundred seed weight (dry)

Hundred seed weight (dry) also followed the same trend and it was significantly highest in the check variety 'Indu' (6.67 g) than *neikumbalam* accessions. Among the accessions, seed weight after drying was highest in BH 7 (5.84 g) followed by BH 9 (4.83 g). It was lowest in BH 12 (3.34 g) which was on par with BH 3, BH 5 and BH 1 (3.42 g, 3.51 g and 3.52 g respectively). Hundred seed weight (dry) among the *neikumbalam* accessions had a mean value of 4.17 g.

4.3.7 Seed viability

Seed viability was tested by Tetrazolium test. Seeds of all accessions and the check variety 'Indu' recorded more than 96 % viability, the highest value recorded in BH 13 (99.33 %). The *neikumbalam* type BH 3 recorded significantly lowest (47 %) seed viability.

4.3.8 Kernel oil

The mean value for seed kernel oil among the accessions was 0.90 %. Kernel oil was highest in the *neikumbalam* type BH 6 (1.07 %). It was comparable to BH 7 and BH 9 (1.03 %), BH 3 and BH 11 (1.02 %), the check variety 'Indu' (0.98 %) and BH 12 (0.97 %). The least amount of seed kernel oil was recorded in BH 2 (0.48 %) and it was on par with BH 4 (0.52 %).

4.4 Phytochemical screening

The sample extracts were analyzed for various phytochemical components. The results have been tabulated in Table 4.10. Ethanol extract of the fruit pulp of medicinal as well as vegetable ash gourd contained the phytochemicals *viz.* tannins, starch, proteins, amino acids, sugars, phenols and glycosides. Steroids and saponins were not detected in both types of ash gourd. The test for flavonoids was positive for fruits of *neikumbalam* as well as those of 'Indu'.

Table 4.10 Phytochemicals present in ash gourd

Sl. No.	Phytochemicals	*Neikumbalam*	Indu
1	Steroids	Absent	Absent
2	Tannins	Present	Present
3	Starch	Present	Present
4	Proteins	Present	Present
5	Amino acids	Present	Present
6	Sugars	Present	Present
7	Phenols	Present	Present
8	Glycosides	Present	Present
9	Flavonoids	Present	Present
10	Saponins	Absent	Absent

4.5 Biochemical characters

The data on the biochemical characters of fully mature fruits have been furnished in Table 4.11a and 4.11b.

4.5.1 pH of fruit juice

pH of fruit juice in the *neikumbalam* accession BH 7 (5.8) was significantly higher than other accessions and the check variety. pH in type BH 3 (5.76) was

78

Table 4.11a Biochemical characters of fruits of *neikumbalam* accessions

Accession No.	pH	Titrable acidity (%)	Total minerals (mg/100g)	Protein (mg/100g)	Starch (%)	Total sugars (g/100g)
BH 2	5.31^{f}	0.45^{b}	364.00^{d}	199.50^{h}	0.67^{a}	1.54^{b}
BH 3	5.76^{ab}	0.38^{cd}	322.00^{f}	305.50^{c}	0.59^{b}	1.24^{d}
BH 4	5.69^{b}	0.43^{bc}	415.00^{a}	230.50^{f}	0.02^{f}	0.87^{g}
BH 6	5.61^{c}	0.57^{a}	394.00^{b}	198.50^{h}	0.73^{a}	0.75^{h}
BH 7	5.80^{a}	0.42^{bc}	329.00^{f}	311.00^{c}	0.38^{c}	0.72^{i}
BH 8	5.18^{g}	0.33^{d}	363.00^{d}	250.50^{d}	0.18^{e}	0.93^{f}
BH 9	5.40^{e}	0.38^{cd}	347.00^{e}	210.00^{g}	0.55^{b}	1.44^{c}
BH 11	5.12^{g}	0.23^{e}	361.00^{d}	343.00^{b}	0.26^{d}	1.11^{e}
BH 12	5.03^{h}	0.62^{a}	380.00^{c}	242.00^{e}	0.25^{d}	0.87^{g}
Mean	5.43	0.42	363.89	254.50	0.40	1.05
Check	5.50^{d}	0.18^{e}	347.00^{e}	440.00^{a}	0.23^{de}	1.66^{a}
CD (5%)	0.07	0.06	12.06	8.47	0.06	0.02

Table 4.11b Biochemical characters of fruits of *neikumbalam* accessions

Accession No.	Total free amino acids (mg/100g)	Total phenols (mg/100g)	Tannins (mg/100g)	Antioxidant activity (IC 50 value)
BH 2	90.80^{c}	104.00^{c}	688.00^{e}	2.595^{a}
BH 3	72.40^{de}	88.00^{e}	640.00^{f}	1.988^{e}
BH 4	109.60^{a}	72.00^{h}	610.00^{g}	2.245^{c}
BH 6	53.60^{g}	80.00^{fg}	960.00^{a}	2.420^{b}
BH 7	53.60^{g}	84.00^{ef}	574.00^{h}	1.934^{f}
BH 8	72.40^{de}	136.00^{a}	914.00^{c}	2.118^{d}
BH 9	74.20^{d}	96.00^{d}	898.00^{d}	1.755^{g}
BH 11	70.40^{e}	76.00^{gh}	944.00^{b}	1.315^{i}
BH 12	93.80^{b}	86.00^{ef}	610.00^{g}	1.683^{h}
Mean	76.76	91.33	759.78	2.01
Check	66.70^{f}	112.00^{b}	920.00^{c}	1.109^{j}
CD (5%)	2.52	7.96	11.66	0.003

comparable to this followed by BH 4 (5.69) and BH 5 (5.61). The mean value for pH of fruit juice among the *neikumbalam* types was 5.43. pH of fruit juice in the check variety 'Indu' was 5.5 and the lowest pH was recorded in the *neikumbalam* type BH 11 (5.03).

4.5.2 Titrable acidity

Titrable acidity among the fruits of *neikumbalam* accessions ranged from 0.23 % to 0.62 % with a mean of 0.42 %. Titrable acidity in fruits of the check variety 'Indu' was significantly lower than all *neikumbalam* accessions (0.18 %) and was on par with BH 11 (0.23 %). The fruits of *neikumbalam* type BH 12 recorded a significantly higher titrable acidity (0.62 %) among all accessions and it was on par with BH 6 (0.57 %).

4.5.3 Total minerals

The total mineral content of fruits among the accessions was significantly highest in BH 4 (415 mg/ 100 g) followed by BH 6 (394 mg/ 100 g) and BH 12 (380 mg/ 100 g). The mean value for total mineral content among the *neikumbalam* types was 363.89 mg/ 100 g. Total mineral content in the check variety 'Indu' was 347 g/ 100g. The least value for this parameter was recorded in BH 3 (322 mg/ 100 g) which was on par to BH 7 (329 mg/ 100 g).

4.5.4 Total free amino acids

The mean value for total amino acid content in fruits of *neikumbalam* accessions was 76.76 mg/ 100 g. The *neikumbalam* type BH 4 recorded significantly highest total amino acid content (109.6 mg/ 100 g) than in other accessions and the check variety 'Indu', followed by BH 12 (93.8 mg/ 100 g) and BH 2 (90.8 mg/ 100 g). Total amino acid content in fruits of the check variety 'Indu' was 66.7 mg/ 100 g. Total amino acid content was least in the fruits of accessions BH 6 and BH 7 (53.6 mg/ 100 g).

81

4.5.5 Protein

The protein content in the *neikumbalam* fruits varied from 198.50 mg/100g to 343 mg/ 100 g with a mean value of 254.5 mg/ 100 g. Protein content in the check variety 'Indu' (440 mg/ 100 g) was significantly higher than all *neikumbalam* accessions. Among the accessions, protein content was highest in BH 11 (343 mg/ 100 g) followed by BH 7 (311 mg/ 100 g) and BH 3 (305.5 mg/ 100 g). The lowest protein content was observed in BH 6 (198.5 mg/ 100 g) and it was on par with BH 2 (199.5 mg/ 100 g).

4.5.6 Total sugars

Total sugar content in fruits of the check variety 'Indu' (1.66 g/ 100 g) was significantly higher than fruits of *neikumbalam* accessions. The mean value for total sugar content of fruits among the accessions was 1.05 mg/ 100 g. Total sugar content among fruits of *neikumbalam* types was highest in BH 2 (1.54 g/ 100 g) followed by BH 9 (1.44 g/ 100 g). It was least in BH 7 (0.72 g/ 100 g).

4.5.7 Starch

The starch content of fruits among the *neikumbalam* accessions showed wide variation with a mean of 0.4 %. Starch content in the type BH 6 (0.73 %) was significantly higher than other accessions and was on par with BH 2 (0.67 %). The fruits of the check variety 'Indu' had a starch content of 0.23 %. Starch content was lowest in BH 4 (0.02 %).

4.5.8 Total phenols

Total phenol content in *neikumbalam* fruits was found to vary from 76 mg/ 100 g to 136 mg/ 100 g with a mean of 91.33 mg/ 100 g. Phenol content was significantly highest in the *neikumbalam* type BH 8 (136 mg/ 100 g) followed by the check variety 'Indu' (112 mg/ 100 g) and BH 2 (104 mg/ 100 g). It was lowest in BH 4 (72 mg/ 100 g) and was comparable to BH 11 (76 mg/ 100 g).

4.5.9 Tannins

The mean tannin content among the fruits of *neikumbalam* accessions was 759.78 mg/ 100 g. Tannin content in the *neikumbalam* type BH 6 (960 mg/ 100 g) was significantly higher than other accessions followed by BH 11 (944 mg/ 100 g) and check variety 'Indu'. Tannin content in fruits of 'Indu' (920 mg/ 100 g) was on par with BH 8 (914 mg/ 100 g). The lowest tannin content was observed in fruits of BH 7 (574 mg/ 100 g).

4.5.10 Antioxidant activity

Antioxidant activity was observed in all the accessions including the check variety. The IC 50 value for the free radical scavenging activity of the fruit extracts among the *neikumbalam* accessions was found to range from 1.315 to 2.595 with a mean value of 2.01. IC 50 value of the fruit extract of the check variety 'Indu' (1.109) was significantly lower than all other accessions. IC 50 value was highest in BH 2 (2.595).

Discussion

5. DISCUSSION

In the present study, sixteen accessions of *neikumbalam* were evaluated for their yield and quality attributes along with a check variety 'Indu'. The check variety represented the vegetable type ash gourd and the other accessions represented the medicinal type ash gourd. Results obtained from the study are discussed in this chapter.

5.1 Evaluation of *neikumbalam* accessions

A survey was conducted for collecting the germplasm of medicinal ash gourd grown in different locations in Southern, Central and Northern Kerala. Sixteen collections of *neikumbalam* (medicinal ash gourd) from different locations in Kerala were evaluated in this study.

5.1.1 Morphological characters

All the *neikumbalam* accessions recorded germination but the percent germination was low. This could be due to the variation in maturity as well as storage period of the collected fruits. The germination per cent in the check variety 'Indu' (66 %) was more than that in all medicinal ash gourd accessions. As in Fig 5.1, the accessions BH 9, BH 4, BH 1 and BH 13 recorded higher germination among the accessions. With respect to days taken for germination, the medicinal ash gourd accession BH 8 germinated earlier than the check variety 'Indu'. Fig 5.1 and Fig 5.2 indicate that the accession BH 4 had both higher germination percentage and lesser number of days to germination.

In a study by Raveendran (2003) in *neikumbalam*, seed germination percentage ranged from 65 % to 95 % and the seeds germinated within 6 days to 9 days.

85

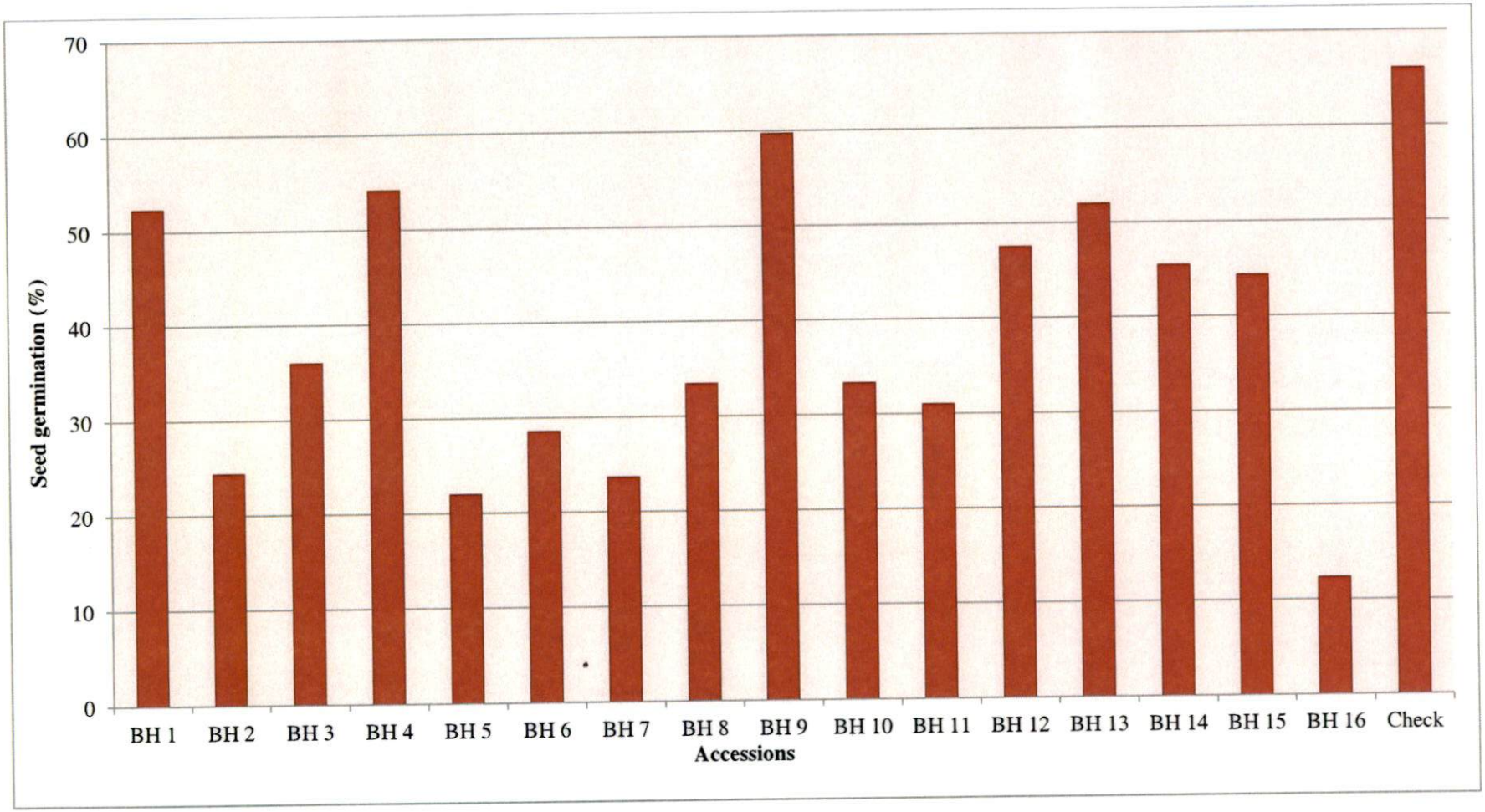


Fig 5.1 Seed germination of *neikumbalam* accessions

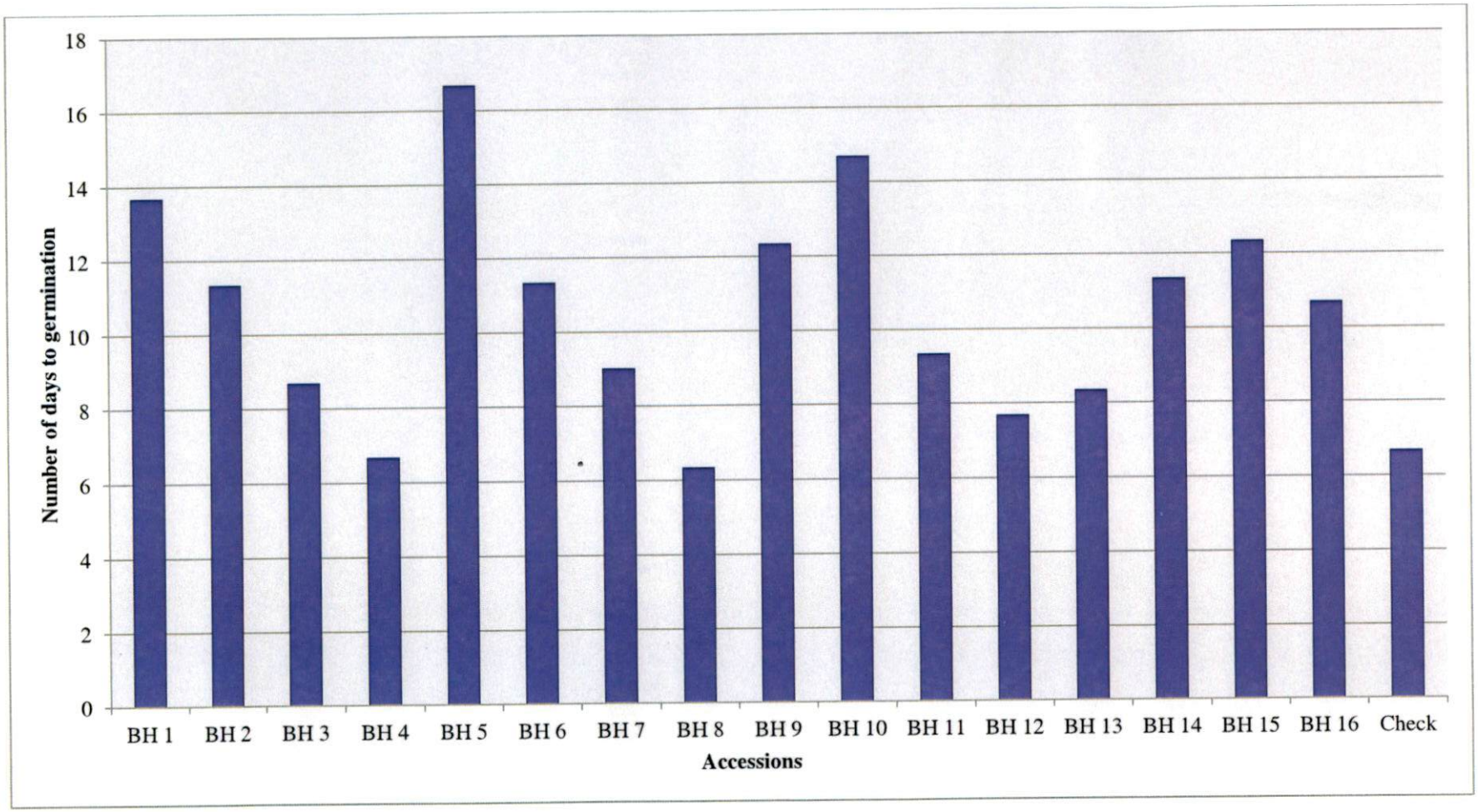


Fig 5.2 Number of days to germination in *neikumbalam* accessions

With respect to vine length, the vegetable ash gourd variety 'Indu' recorded faster growth at all growth stages than the medicinal ash gourd accessions. The accession BH 11 had the fastest growth among these accessions, having the highest vine length at all growth stages. At the flowering stage, vine length among the accessions ranged from 39.75 cm to 212.55 cm.

Latif *et al.* (2008) have reported that the vine length in exotic monoecious genotypes of ash gourd at first male flower opening stage ranged from 89 to 126 cm, and in local genotypes, it ranged from 301 to 314 cm. In the case of first female flower opening, the height of exotic monoecious genotypes ranged from 93 to 128 cm and that of local genotypes ranged from 306 to 324 cm. Nagaraju *et al.* (2016) had recorded a vine length of 315.62 cm and 396.67 cm in Indu and *vaidyakumbalam* respectively. Dobre (2013) in his study had reported vine length to vary between 1.86 m and 5.8 m. Dewan *et al.* (2014) observed that vine length of plant is significantly and positively correlated with sex ratio and yield per plant and hence vine length could be a yield contributing factor in *neikumbalam* types.

Similar to vine length, Indu produced more number of primary branches also than all medicinal ash gourd accessions (4.66, 7.75, 8.84 and 9.06 respectively at the four stages). Among the accessions, BH 7 recorded highest number of branches at pre flowering and harvest stages (4.12 and 8.08) and BH 11 and flowering and fruiting stages (5.84 and 7.4).

Singhal (2008) had observed that the number of primary branches in the ash gourd accessions in her study varied from 5 to 10.25. Variation in number of primary branches was also reported by Bairwa (2016), the number of branches ranging from 9 to 13.67. It ranged from 9.67 to 14 in a study by Sahu *et al.* (2005). Dobre (2014) has reported from a field study in Romania that the number of primary branches varied from 1 to 8 in ash gourd.

Number of leaves per plant was also higher in the check variety Indu than the medicinal ash gourd accessions at the pre flowering, flowering and fruiting stages. The accession BH 11 produced more number of leaves at harvest stage. Number of

leaves per plant at flowering stage among these accessions ranged from 31.1 to 105.95.

According to Latif *et al.* (2008), most of the exotic monoecious ash gourd types produced 17 to 27 leaves at the first male flower anthesis whereas indigenous types flowered later than the exotic materials and they had 66 to 70 leaves at first male flowering. Number of leaves was 17 to 28 in exotic monoecious materials at first female flower anthesis. Local types produced 68 to 73 leaves at this stage.

Leaves of vegetable ash gourd were larger in size than those of medicinal ash gourd. As seen in Fig 5.3, only a single accession (BH 11) recorded a slightly higher leaf area than Indu. The accession with the least leaf area, BH 8 also had lower number of primary branches and number of leaves.

Results of the observations on morphological parameters recorded at four growth stages of the crop revealed that the medicinal ash gourd accessions were less vigorous in growth, producing lower number of branches and leaves and smaller leaves when compared to its vegetable counterpart 'Indu'.

5.1.2 Flowering characters

Ash gourd is a monoecious crop, producing male and female flowers separately on the same plant. In general, in ash gourd, male flowers appear first and female flowers later. Data on flowering characters presented in Table 4.5 revealed that the accession BH 16 took the least number of days to first male flower (59 days) as can be seen from Fig 5.4. Male flowers in the accessions BH 14, BH 13 and BH 15 also opened earlier than male flowers in Indu, the check. Male flower opening in some accessions took place as late as 115 days (BH 7).

Singhal (2008) in her study reported that the days to opening of first male flower ranged from 46 days to 81 days. It varied from 59.67 days to 74.33 days in a study by Bairwa (2016). Latif *et al.* (2008) observed that anthesis of first male and female flowers of exotic types were earlier than the local materials. Hamid *et al.*

89

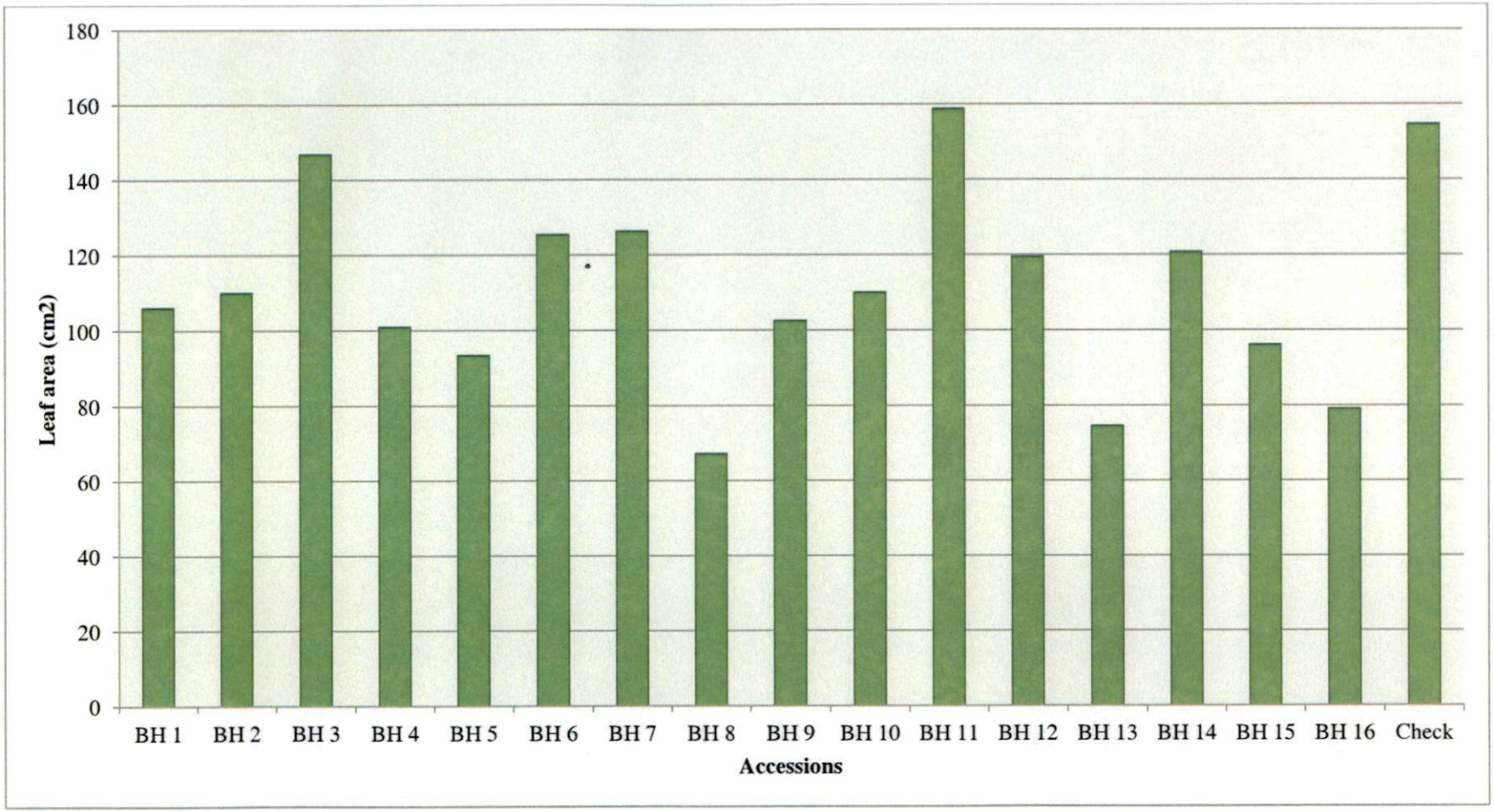


Fig 5.3 Leaf area in *neikumbalam* accessions

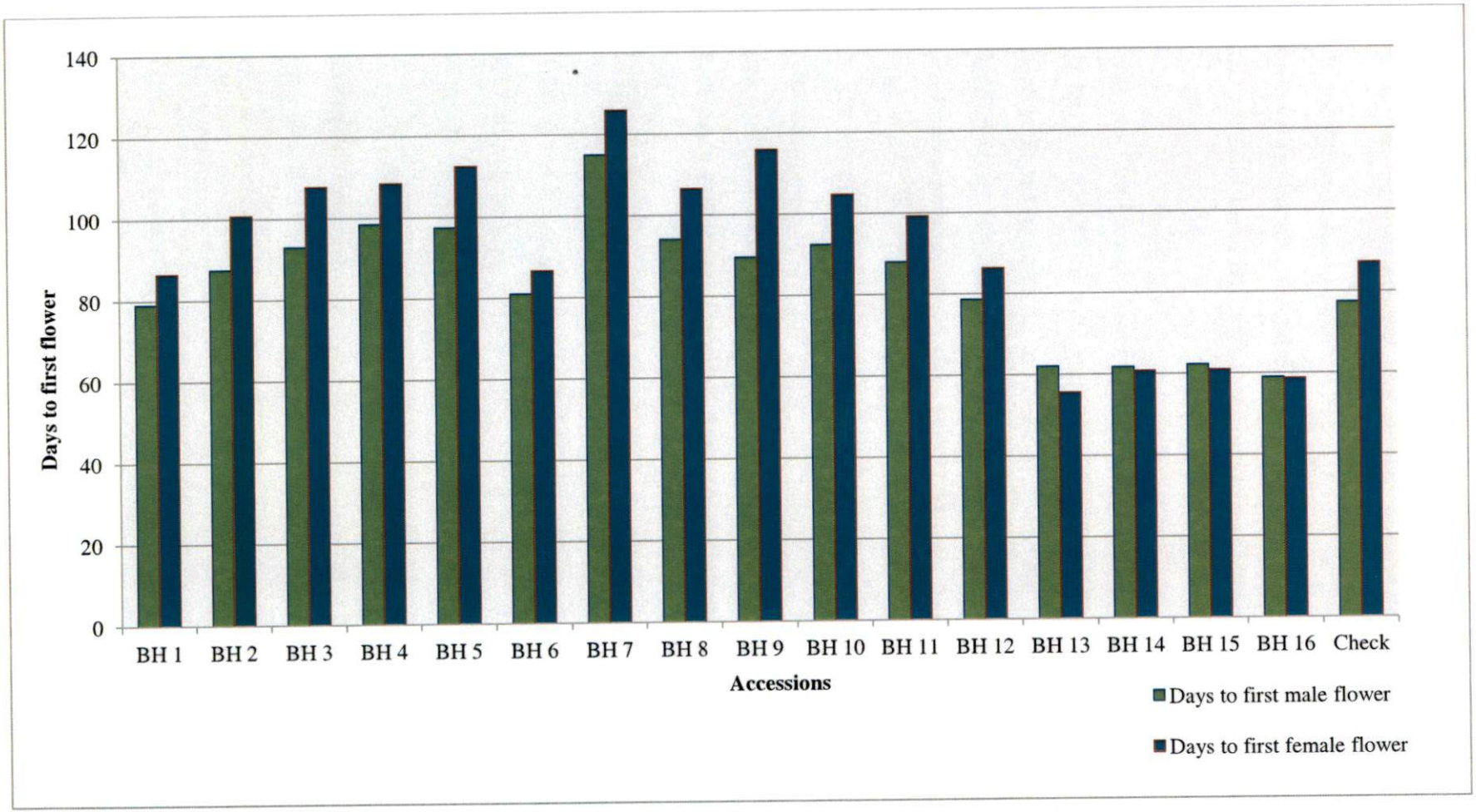


Fig 5.4 Days to first flower in *neikumbalam* accessions

(1989) reported that local types of ash gourd produced first male flower within 41 to 59 days, whereas the female flower opened in 51 to 70 days.

In the present study, the accession BH 13 took the least number of days to first female flower opening (55.62 days). As seen in Fig 5.4, the accessions BH 16, BH 14, BH 15, BH 1 and BH 6 also reported earlier opening of female flower than in Indu.

Days to first female flower opening ranged from 58.17 to 75.66 days in a study by Singhal (2008) in ash gourd. Bairwa (2016) had reported days to first female flower to range from 65 to 89 days. In another study by Nagaraju *et al.* (2016) in *Benincasa hispida* accessions, days taken to first female flower in Indu and *vaidyakumbalam* were 59.75 days and 72.31 days respectively. Rahman *et al.* (1986) had found significant difference for days to first flowering in different cucurbits like ribbed gourd, bitter gourd and sweet gourd. They concluded that days to male flowering were lesser than those to female flowering in these cucurbits. But in contrast to this, it was observed in the present study that opening of first female flower took place earlier than first male flower in the accessions BH 13, BH 14, BH 15 and BH 16.

The first male flower was produced at a lower node than in the check variety Indu (11.88) in the accessions BH 16, BH 6, BH 12, BH 3, BH 7, BH 1, BH 13, BH 2 and BH 8 as can be seen from Fig 5.5. The lowest node to first male flower was observed in BH 16 (7 nodes) and at the highest node in BH 11 (18th node).

Singhal (2008) had reported that node to first male flower in vegetable ash gourd accessions ranged from 18.25 to 34. Latif *et al.* (2008) reported that node number at which first male flower opened differed from one genotype to another. In both exotic and local genotypes, the male flowers appeared earlier at lower node as compared to the female flowering node. Hamid *et al.* (1989) observed in their study that the first male flower appeared with the node order of 10 to 13 in some local genotypes and 22 to 28 in other genotypes of their study.

92

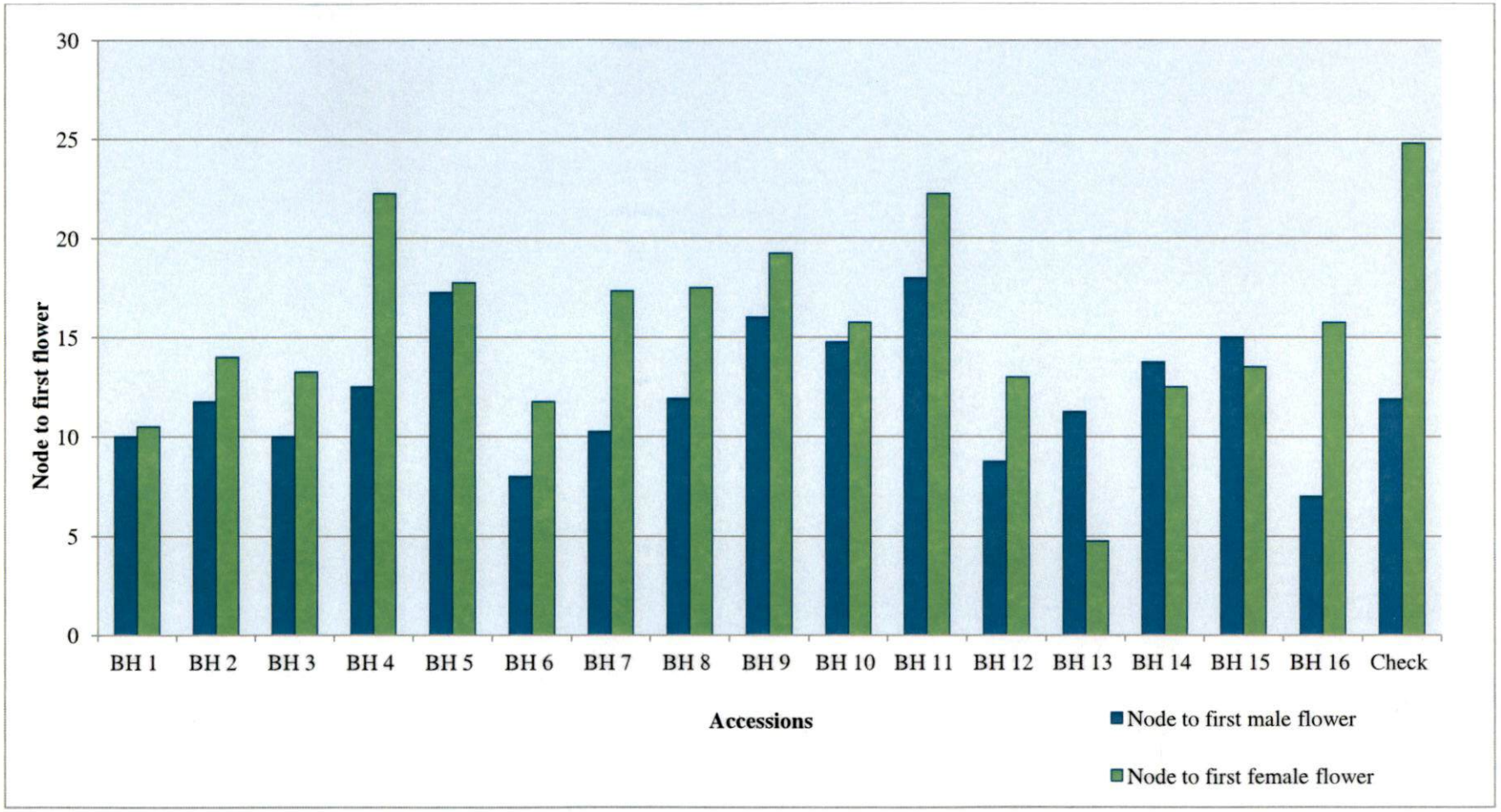


Fig 5.5 Nodes to first flower in *neikumbalam* accessions

Node number to first female flower was higher in the check variety Indu than all medicinal ash gourd accessions. Seshadri (1986) and Rashid (1999) reported that the male flowers appeared at the lower node than the female flowers. However, in the present study, as shown in Fig 5.5, it was observed that the first female flower was produced at a lower node than first male flower in the accessions BH 13, BH 14 and BH15.

Node number to first female flower ranged from 28.25 to 45 in a study by Singhal (2008). Rao and Sushama (2014) in their study observed that the first female flower appeared at 14th node. Thamburaj and Kamalanathan (1973) observed that there was positive correlation between flowering (male or female) at lower nodes and earliness of flowering. In accordance with this, it was observed in the present study that the accession BH 13 which showed early female flowering (55.62 days) also produced the first female flower at a lower node (4.75). And, the accession BH 9 with late opening of first female flower (116 days) produced the female flower at a higher node (19.25). Similarly, the accession BH 16 in which the first male flower opened early (59 days) produced the flower at a lower node (Node 7).

With respect to the total number of flowers produced per plant, the vegetable ash gourd variety 'Indu' produced more male flowers (42.46) than all medicinal ash gourd accessions as shown in Fig 5.6. Two accessions, BH 2 and BH 6 produced more female flowers (6 and 5 respectively) than 'Indu' (4.79).

According to Latif *et al.* (2008), number of female flowers per plant varied from 6 to 16 in a study among exotic ash gourd genotypes. In local genotypes, the range of female flowers was 6 to 10 only. Kamalanathan *et al.* (1972) reported that there was significant and positive correlation between incidence of female flowers at lower nodes and number of female flowers per vine.

Sex ratio is an important yield contributing parameter in any monoecious cucurbit. Lower sex ratio is always associated with high yield. In the present study, sex ratio in vegetable ash gourd variety 'Indu' (9.37) was found to be higher than medicinal ash gourd accessions. As seen in Fig 5.7, the *neikumbalam* type BH 15 (8.52) recorded the highest sex ratio among the accessions and the lowest sex ratio

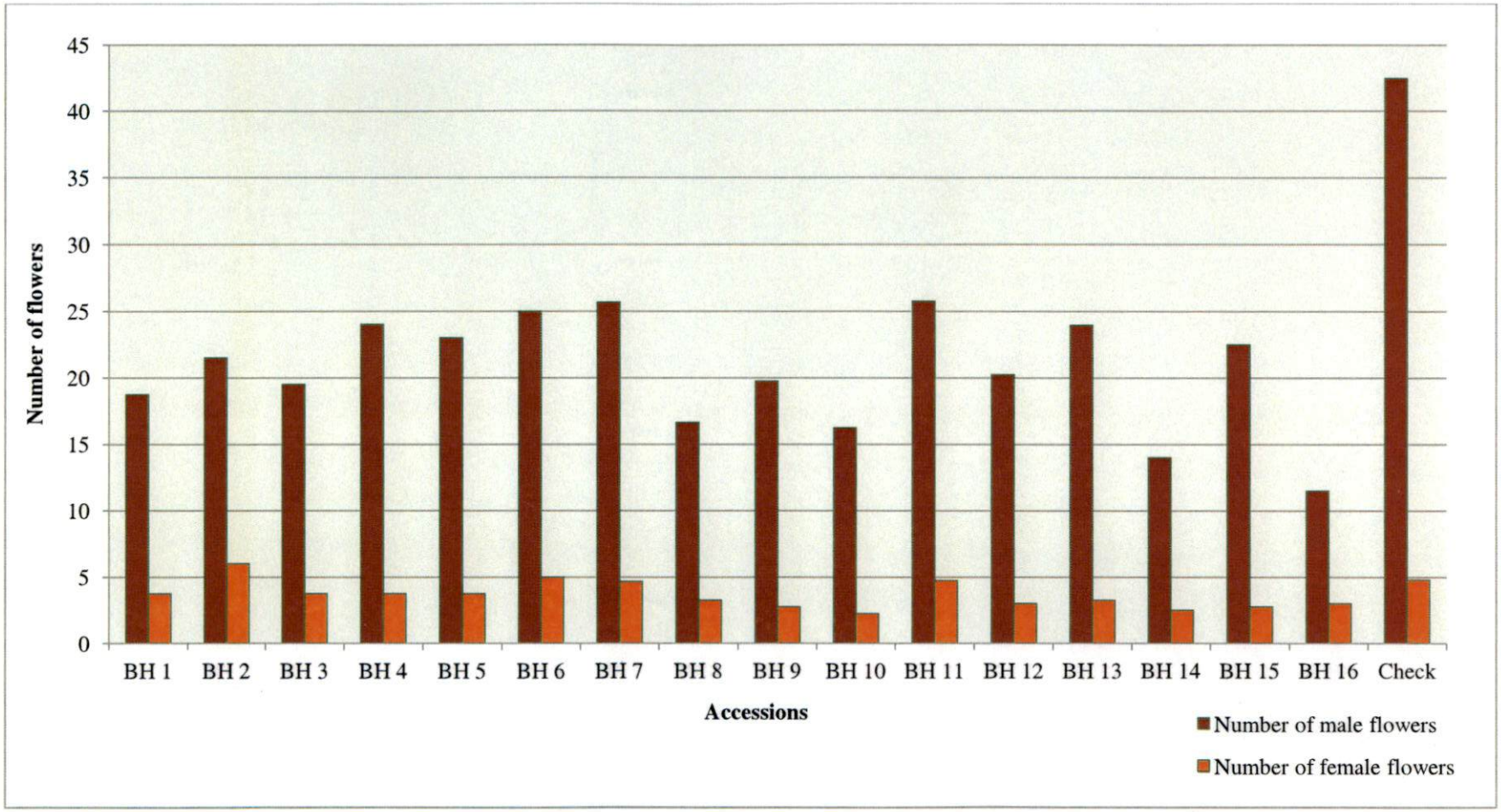


Fig 5.6 Number of flowers in *neikumbalam* accessions

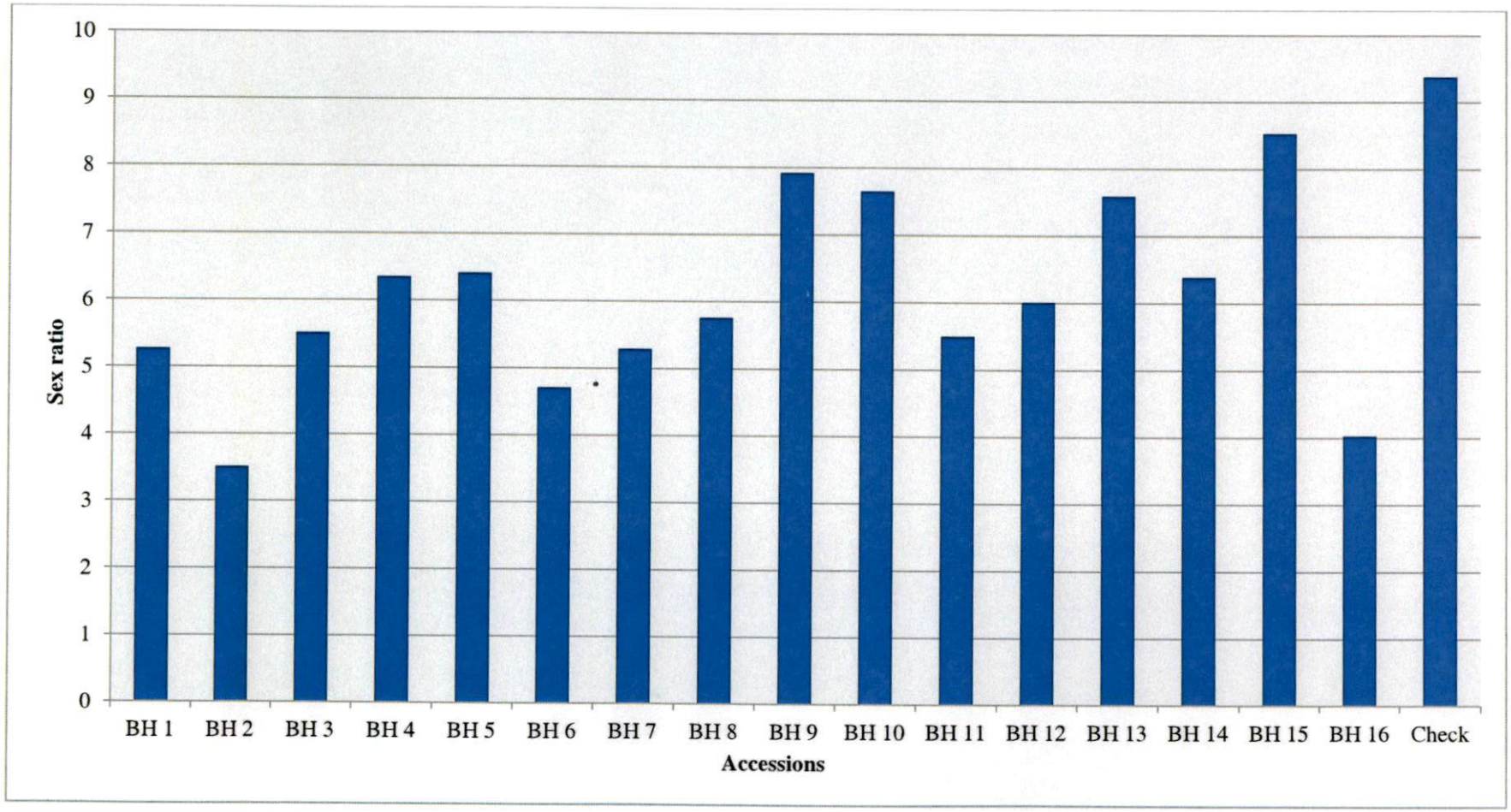


Fig 5.7 Sex ratio in *neikumbalam* accessions

of 3.5 was recorded in BH 2. Lower sex ratio indicates higher number of female flowers and lower number of male flowers.

Dewan *et al.* (2014) observed that sex ratio was negatively correlated with yield per plant. Observations on flowering characters in Table 4.5 and yield parameters in Table 4.6 revealed that BH 2 with a lower sex ratio (3.5) had higher yield in terms of number of fruits per plant than other *neikumbalam* accessions.

The results of the observations on flowering characters revealed that the accessions BH 13, BH 14, BH 15 and BH 16 were early not only in female flower opening but also produced female flowers at lower nodes than other accessions. Also, all *neikumbalam* accessions had a sex ratio lesser than the check variety 'Indu'.

5.1.4 Yield and yield parameters

Fruit set (per cent) showed variation among the medicinal ash gourd accessions, ranging from 22.5 % (BH 1) to 75 % (BH 14). Fruit set percent in the check variety Indu was 51.92 %. Latif *et al.* (2008) observed that the fruit set in a plant is directly related with female flower production.

The vegetable ash gourd variety 'Indu' produced more number of fruits per plant (2.54) than most medicinal ash gourd accessions, except BH 7 which produced 2.84 fruits per plant. This character assumes importance as yield depends on the number of fruits per plant.

According to Raveendran (2003), fruits per plant showed significant difference among *neikumbalam* accessions. It ranged from 1.35 to 4.86 fruits per plant in her study. In a study by Bairwa (2016), it was observed that the number of fruits per plant ranged from 7.24 to 13. Number of fruits per plant ranged from 8 to 14 in a study by Sahu *et al.* (2015). Singhal (2008) observed that fruit per plant ranged from 0.2 to 5 in her study among ash gourd genotypes. Dewan *et al.* (2014) observed that number of fruits per plant had highly significant positive correlation

97

with yield per plant. This was also observed by Kumaran *et al.* (1998), Ahmed *et al.* (1995) and Rana *et al.* (1995) in their studies on ash gourd. Rao and Sushama (2014) observed that the economical characters *viz.* number of fruits per plant, fruit weight and fruit yield are very important in ash gourd.

Fruit yield per plant for *neikumbalam* accessions in the present study ranged from 0.46 kg to 3.48 kg with a mean of 1.21 kg per plant. The check variety 'Indu' recorded a significantly higher yield of 6.13 kg per plant than all *neikumbalam* types. Among the *neikumbalam* types, BH 7 recorded the highest fruit yield (3.48 kg). The lowest fruit yield was recorded in the types BH 16 (0.46 kg per plant) and BH 12 (0.49 kg per plant).

Raveendran (2003) reported that *neikumbalam* accessions differed significantly in fruit yield per plant. It ranged from 0.41 kg to 4.92 kg. In a study by Singhal (2008) in ash gourd, the fruit yield per plant ranged from 4.75 kg to 38.31 kg.

There was variation in the number of days taken for fruit maturity among the medicinal ash gourd accessions, ranging from 33.5 days (BH 10) to 45.12 days (BH 8). The vegetable ash gourd variety 'Indu' took 38.23 days for the same.

Variability in days to first fruit set and days to first fruit harvest in ash gourd was also observed by Sahu *et al.* (2015) and Bairwa (2016). Mean days to first fruit set ranged from 72.27 days to 99 days (Bairwa, 2016) and from 68.67 days to 97 days (Sahu *et al.*, 2015). Days taken to first fruit harvest ranged from 125.47 days to 136.67 days. (Bairwa, 2016) and from 124.33 days to 134.33 days (Sahu *et al.*, 2015)

The crop duration ranged from 102.66 days (BH 16) to 153 days (BH 9) among the medicinal ash gourd accessions in the present study as shown in Fig 5.8. Crop duration recorded in the vegetable ash gourd variety 'Indu' was 136.88 days.

Sahu *et al.* (2015) and Bairwa (2016) had also reported the narrow variation present in crop duration among different ash gourd genotypes. According to Sahu *et*

98

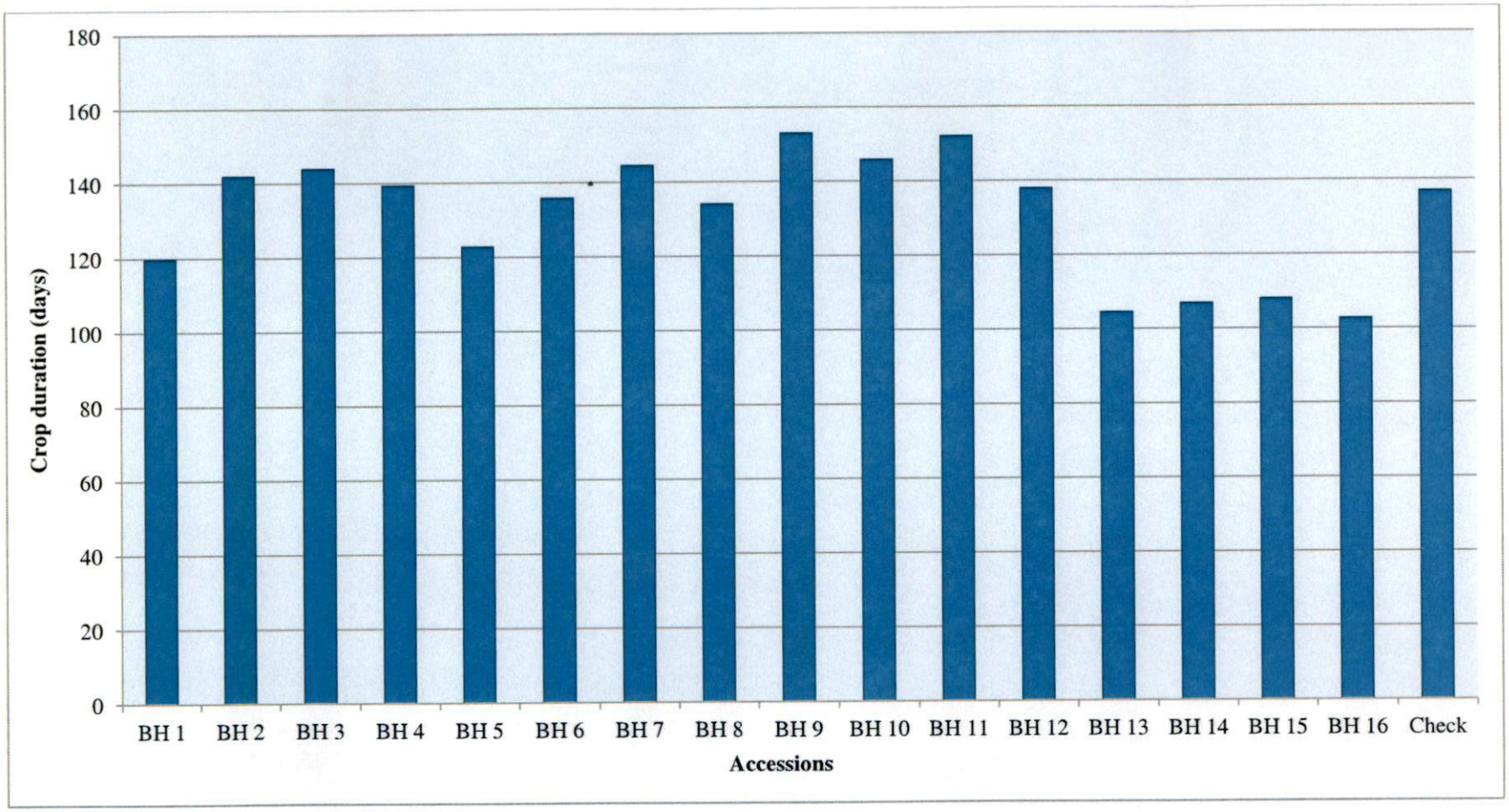


Fig 5.8 Crop duration in *neikumbalam* accessions

al. (2015), duration of crop ranged from 133 days to 146.33 days. It ranged from 134 days to 147.33days in the study by Bairwa (2016).

5.1.5 Fruit characters

Variability was observed in all the qualitative fruit characters studied. Variation in fruit shape was observed by various workers in ash gourd, *i.e.* oblong, oblate (Seshadri, 1986), cylindrical, spindle shaped, round (Gangopadhyay *et al.*, 2008), long, oblong, round oblong, round, flat round (Singhal, 2008), cylindrical and club shaped fruits (Bairwa, 2016).

In the present study, oblong fruits were observed in seven accessions (BH 1, BH 2, BH 3, BH 6, BH 7, BH 8 and BH 12), spherical fruits in three accessions (BH 4, BH 5 and BH 11) and conical fruits in two accessions (BH 9 and BH 10). The check variety 'Indu' produced oblong fruits.

At edible or immature stage, the fruits were covered with pointed whitish hair which disappeared gradually with maturity and a waxy layer was formed on the skin. Hairiness was low in the check variety 'Indu' and majority of the *neikumbalam* accessions (BH 1, BH 3, BH 6, BH 7, BH 8, BH 9, BH 10, and BH 11). It was medium in two accessions (BH 4 and BH 5) and hairiness was high in two other accessions (BH 2 and BH 12). Seshadri (1986) reported that the waxy coat of ash gourd fruit ensures outstanding storage quality. The intensity of waxiness also varied among the accessions. Waxiness over the fruit surface was low in the accessions BH 6 and BH 10, of medium intensity in majority of the accessions (BH 1, BH 2, BH 3, BH 8, BH 9 and BH 12) and in the check variety 'Indu'. Waxiness was high in the accessions BH 4, BH 5, BH 7and BH 11.

It was observed that five accessions had dark green rind colour (BH 1, BH 3, BH 6, BH 7 and BH 8), two accessions bright green rind colour (BH 2 and BH 11), one accession yellowish green rind colour (BH 4) and four accessions (BH 5, BH 9, BH 10 and BH 12) and the check variety 'Indu' had light green rind colour.

100

The keeping quality of fruits ranged from 6 weeks (BH 3, BH 9 and BH 10) to 11 weeks (BH 4 and BH 5). The check variety 'Indu' had a keeping quality of 7 weeks.

Fruit size exhibited wide variation among the accessions. The fruit size of medicinal ash gourd was smaller than vegetable ash gourd as shown in Table 4.8. It can be seen from Fig 5.9 that fruit length showed considerable variation among the accessions. It varied from 9.8 cm to 24 cm among the accessions. The check variety 'Indu' recorded significantly higher fruit length than the *neikumbalam* accessions (29.20 cm).

Raveendran (2003) observed that *neikumbalam* accessions differed significantly in fruit length recording a maximum fruit length of 16.86 cm. Nagaraju *et al.* (2016) had reported that fruits of 'Indu' were longer than that of *vaidyakumbalam.* According to Dewan *et al.* (2014), fruit length was significantly and positively correlated with average weight per fruit and with vine length and yield per plant.

As in Fig 5.9, Fruit diameter in the vegetable ash gourd variety 'Indu' (14.8 cm) was higher than the medicinal ash gourd accessions, among which it varied from 7.9 cm (BH 12) to 13.6 cm (BH 5).

Raveendran (2003) observed that fruit diameter among *neikumbalam* accessions varied significantly recording a maximum fruit diameter of 11.31 cm. Dewan *et al.* (2014) noticed that diameter of fruit had significant and positive correlation with average weight per fruit. It was also positively correlated with number of fruits per plant and yield per plant.

The fruits of vegetable ash gourd were heavier than medicinal ash gourd fruits as seen in Fig 5.10. Fruit weight recorded in the vegetable ash gourd variety 'Indu' was 2380 g. Fruit weight among the medicinal ash gourd accessions varied from 349 g (BH 12) to 1250 g (BH 7).

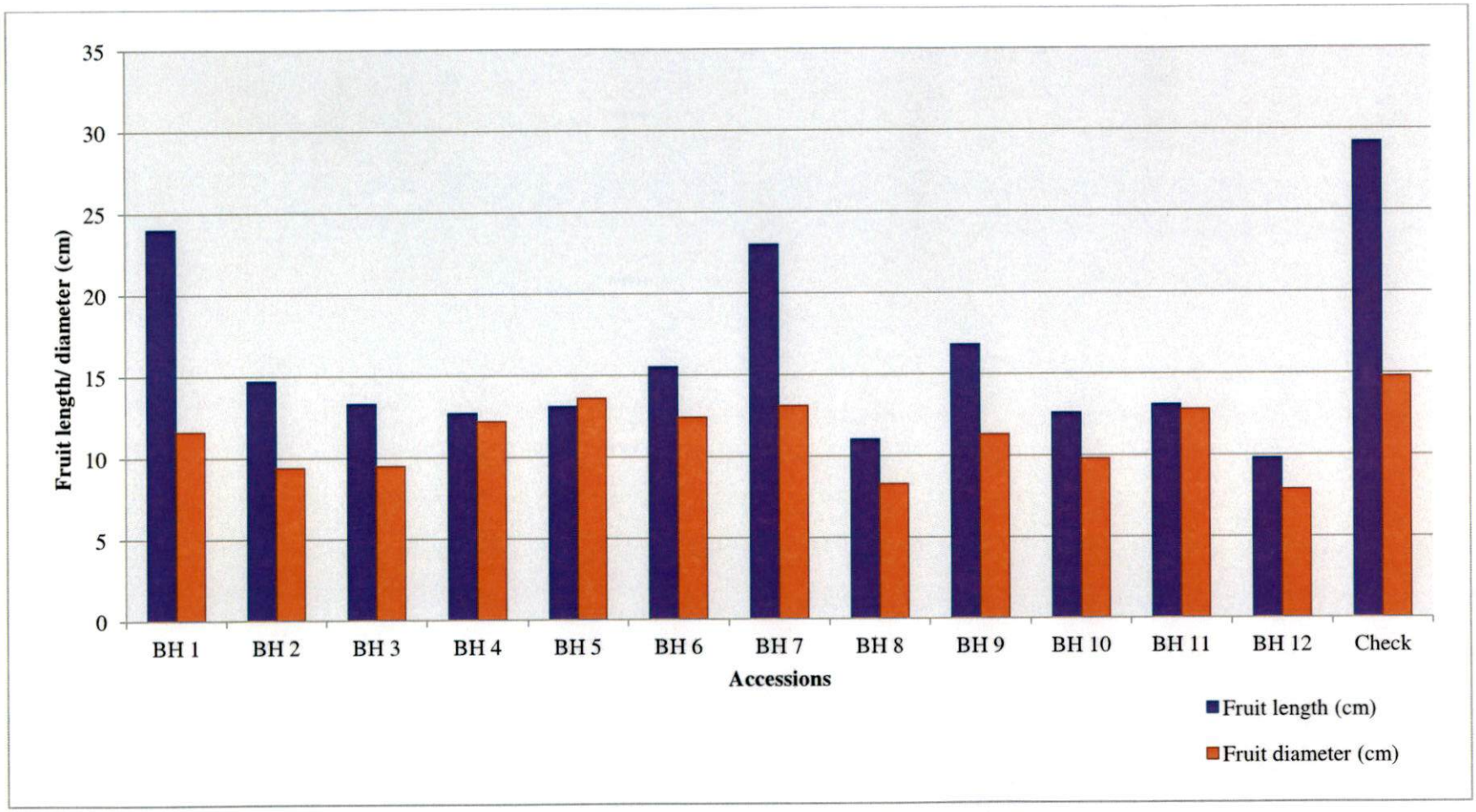


Fig 5.9 Fruit length and fruit diameter in *neikumbalam* accessions

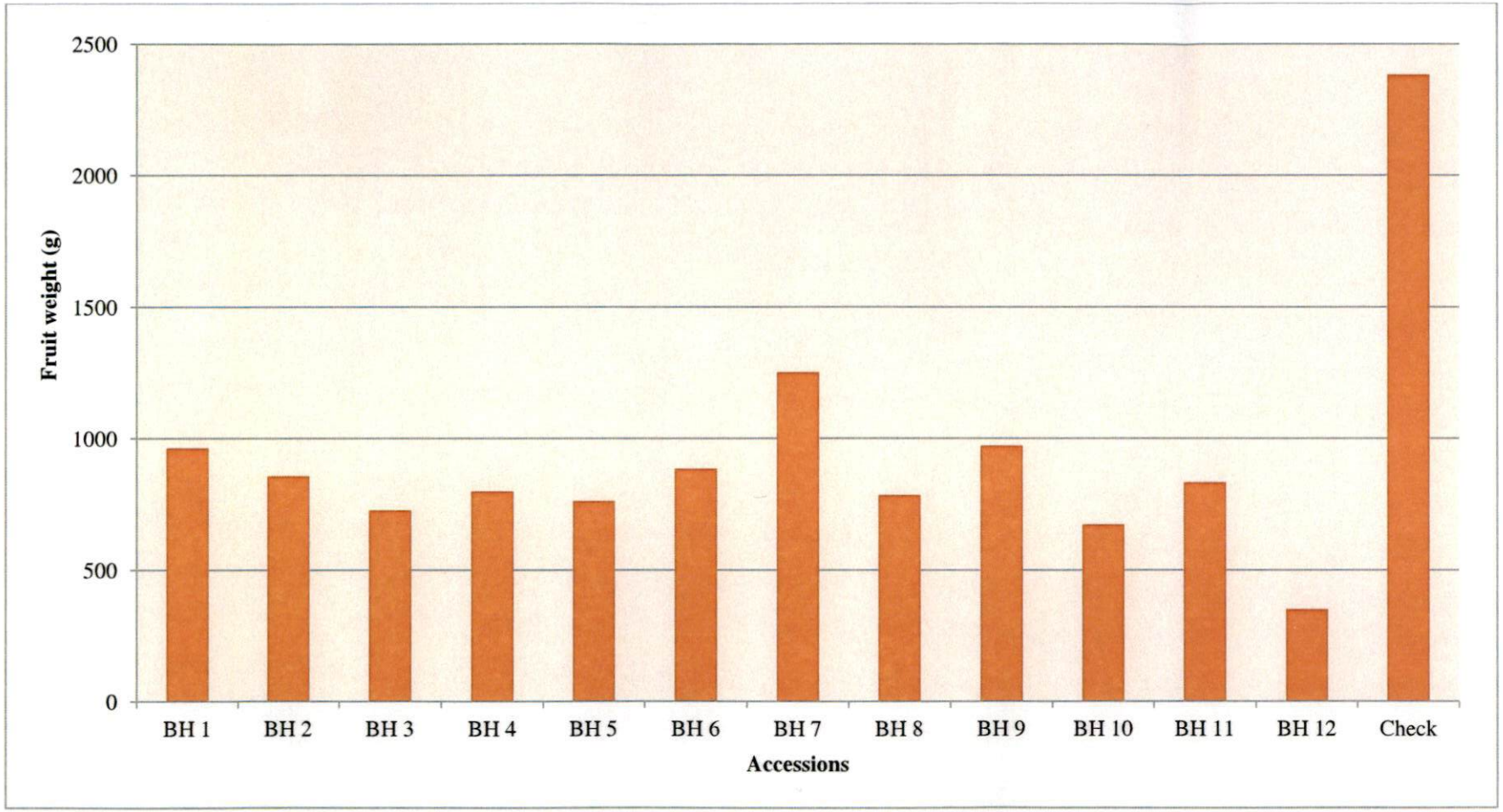


Fig 5.10 Fruit weight of *neikumbalam* fruits

Raveendran (2003) reported that *neikumbalam* accessions in her study differed significantly in fruit weight from 0.2 to 1.31 kg. Average fruit weight ranged from 2.24 kg to 3.35 kg in a study by Sahu *et al.* (2015). Dewan *et al.* (2014) observed that fruit weight was significantly and positively correlated with yield per plant. In the present study, the vegetable ash gourd variety 'Indu' with the highest single fruit weight also recorded the highest fruit yield per plant. Similarly, BH 7 recorded high fruit weight and also high fruit yield per plant among the *neikumbalam* accessions. The accession BH 12 with a low single fruit weight of 349 g also had a very low fruit yield (0.49 kg) per plant.

Rind thickness was significantly higher in the check variety 'Indu' (3.33 mm) than all *neikumbalam* accessions as shown in Fig 5.11. Among the *neikumbalam* types, rind thickness was highest in BH 3 (2.67 mm). Rind thickness was found to be the lowest in BH 4 (1.33 mm).

Raveendran (2003) also reported that there was significant difference in rind thickness among different *neikumbalam* accessions. A maximum rind thickness of 1.96 mm was recorded by her.

Flesh thickness was also higher in the vegetable ash gourd variety 'Indu' than medicinal ash gourd accessions as shown in Fig 5.11. There was variability for these characters among the medicinal ash gourd accessions also. Flesh thickness ranged from 12 mm (BH 12) to 23.33 mm (BH 7).

Raveendran (2003) reported that *neikumbalam* accessions her study differed significantly in flesh thickness. A maximum flesh thickness of 11.07 cm was observed among the accessions. Dewan *et al.* (2014) observed that flesh thickness of fruit was positively correlated with average weight per fruit, vine length and yield per plant.

Observations on the fruit characters showed that the *neikumbalam* accession BH 7 produced more number of fruits per plant compared to the check variety Indu. But because of smaller size of fruits, the fruit yield (kg) was lesser than that recorded in 'Indu', the check variety.

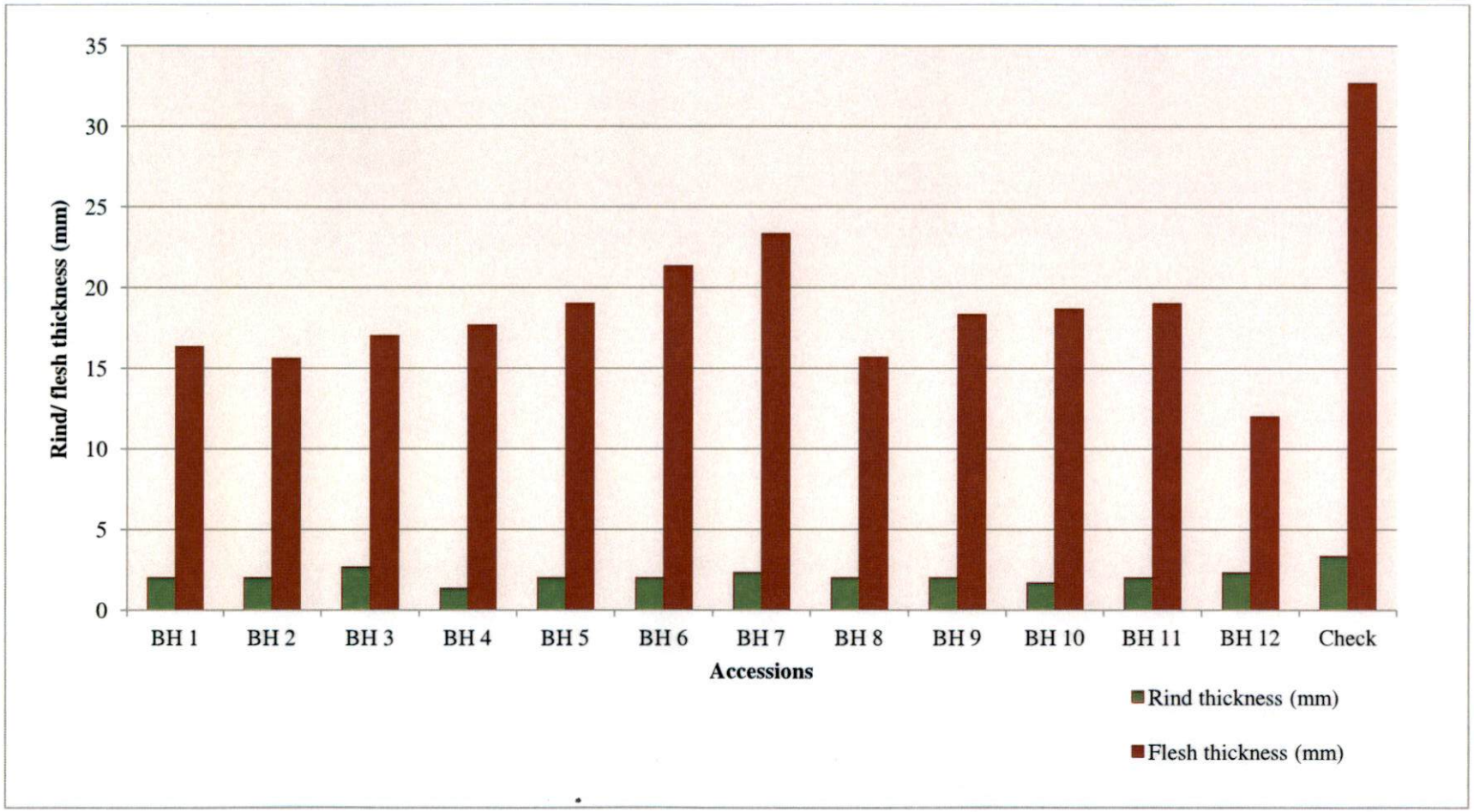


Fig 5.11 Rind and flesh thickness in fruits of *neikumbalam* accessions

5.1.6 Seed characters

Seeds of *neikumbalam* were small compared to normal ash gourd seeds. Seed length in the check variety 'Indu' (12 mm) was significantly higher than other *neikumbalam* types. The least seed length was recorded in BH 11 (9.17 mm). Seed breadth among the accessions ranged from 4.50 mm to 7 mm. Significantly highest seed breadth was recorded in BH 7 (7 mm). Seed breadth was found to be lowest in BH 10 (4.5 mm).

The *neikumbalam* type BH 7 recorded significantly highest number of seeds per fruit (739) than all other accessions as shown in Fig 5.12. Number of seeds in the fruits of the check variety 'Indu' was 523 per fruit. The lowest number of seeds was recorded in BH 11 (252 seeds).

Number of seeds per fruit ranged from 247.69 to 680.35 in a study by Bairwa (2016) in ash gourd. Singhal (2008) reported number of seeds to range from 354 to 1310 per fruit.

Seed coat weight in the check variety 'Indu' (36.96 mg) was significantly higher than *neikumbalam* types. Among the accessions, the highest value for weight of seed coat was recorded in BH 7 (32.18 mg). Seed coat weight was the lowest in BH 12 (17.96 mg). Weight of seed kernel in the check variety 'Indu' (31.62 mg) was significantly highest compared to *neikumbalam* accessions. Among *neikumbalam* accessions, seed kernel weight was highest in BH 7 (26.78 mg). Weight of seed kernel was least in BH 5 (15.78 mg).

The hundred seed weight of freshly extracted seeds was found to be significantly highest in the check variety 'Indu' (7.23 g). Among the accessions, it was highest in BH 7 (6.02 g). The least value for hundred seed weight (fresh) was recorded in BH 3 (3.61). Hundred seed weight (dry) also was significantly highest in the check variety 'Indu' (6.67 g) than *neikumbalam* accessions. Among the accessions, seed weight after drying was highest in BH 7 (5.84 g). It was lowest in BH 12 (3.34 g).

106

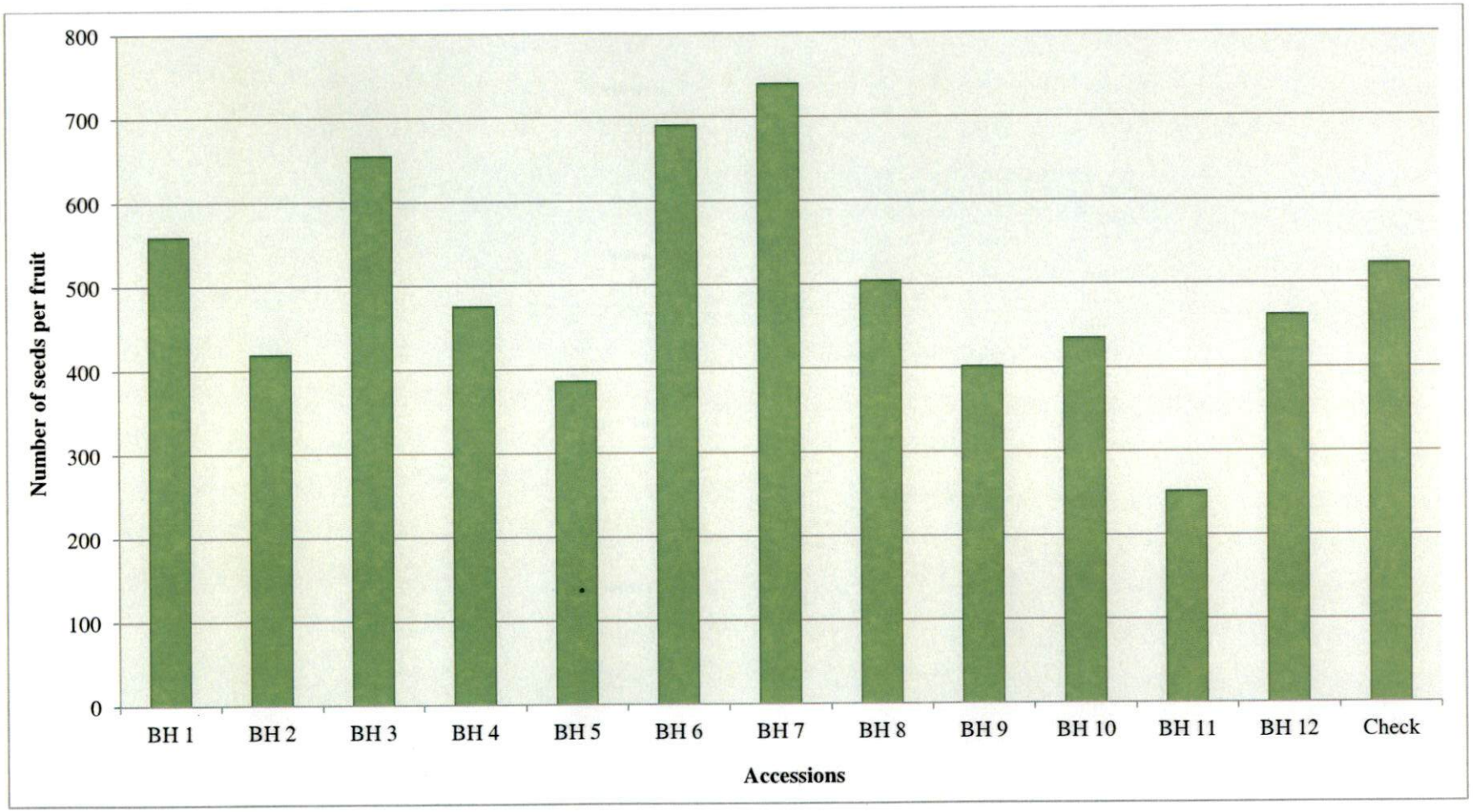


Fig 5.12 Number of seeds in *neikumbalam* fruits

Hundred seed weight in a study by Bairwa (2016) ranged from 2.87g to 6.67 g. Sahu *et al.* (2015) observed that hundred seed weight ranged from 3.33 g to 6.10 g. A mean value of 4.810 g for hundred seed weight was observed by Afroze (2006).

Seeds of all accessions and the check variety 'Indu' recorded more than 96 % viability, the highest value recorded in BH 13 (99.33 %). The *neikumbalam* type BH 3 recorded significantly lowest (46.67 %) seed viability.

Kernel oil was highest in the *neikumbalam* type BH 6 (1.07 %). The least amount of seed kernel oil was recorded in BH 2 (0.48 %). Sew *et al.* (2010) reported that due to high amounts of poly unsaturated fatty acids, ash gourd seeds had favourable nutritional status and beneficial physiological effects. Ash gourd seeds and seed oil are also considered as antihelmintic as reported by Pandey *et al.* (2015). Ash gourd seed contains oil which contains a high proportion of an essential fatty acid, linoleic acid, accounting for 67.37% of the total fatty acids. Asolkar *et al.* (2000) reported that seed kernel can be used against skin eruption and is one of the ingredients in drug preparation for appendicitis.

Observations on various seed characters showed that *neikumbalam* seeds were small compared to the vegetable ash gourd seeds. Seeds of BH 12 were the smallest in size and least in weight. The hundred seed weight was also more in vegetable ash gourd.

5.1.7 Biochemical characters

Fully mature fruits were subjected to biochemical analysis and the results are discussed here. The initial screening for phytochemicals indicated the presence of tannins, starch, proteins, amino acids, sugars, phenols, glycosides and flavanoids both in the *neikumbalam* as well as the check variety. Steroids and saponins were absent in the fruit extract of both types.

pH of fruit juice in the *neikumbalam* accession BH 7 (5.8) was significantly higher than other accessions and the check variety as seen in Fig 5.13. pH of fruit juice in the check variety 'Indu' was 5.5 and the lowest pH was recorded in the *neikumbalam* type BH 11 (5.03).

108

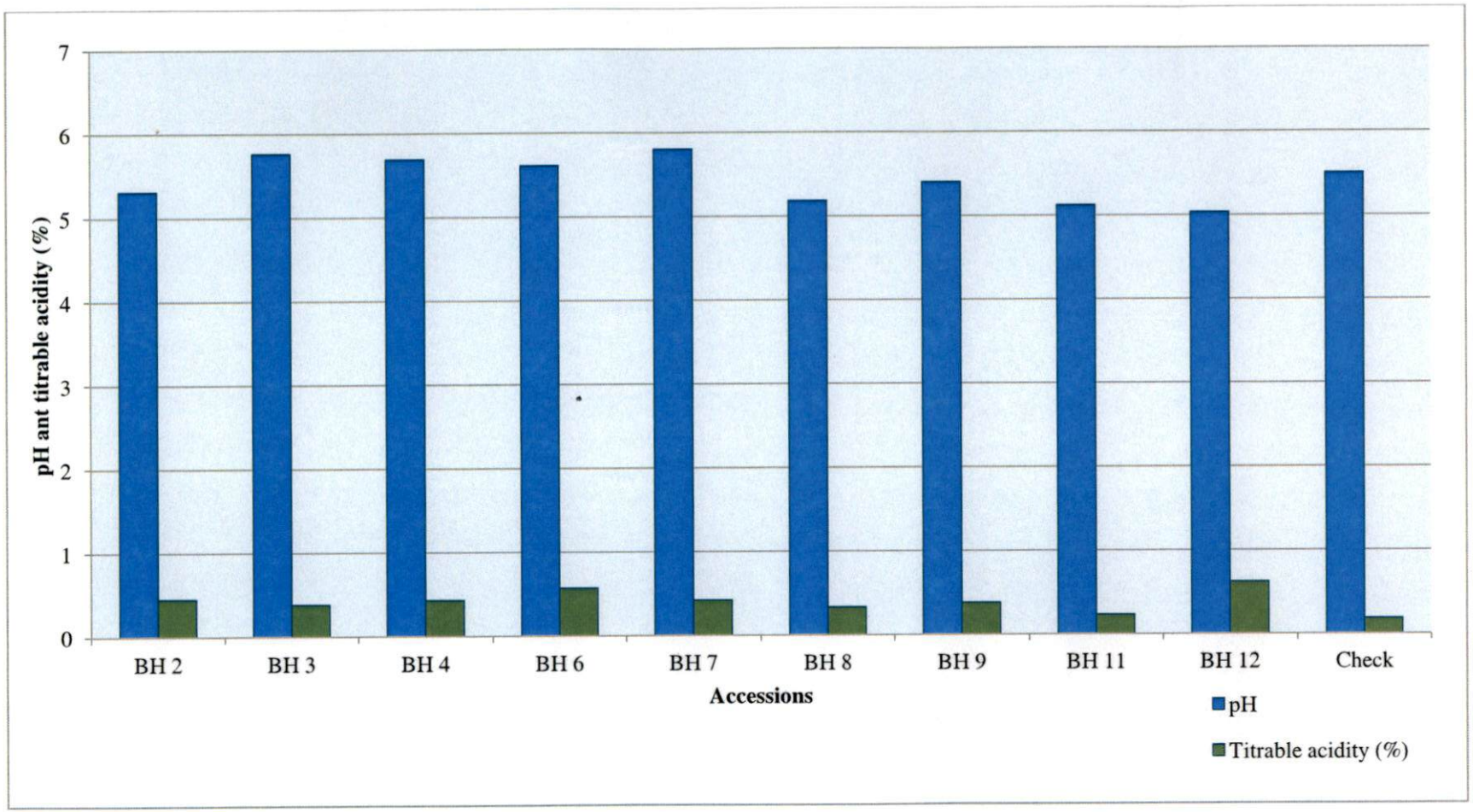


Fig 5.13 pH and titrable acidity of *neikumbalam* fruits

Acidity among the fruits of *neikumbalam* accessions ranged from 0.23 % to 0.62 % with a mean of 0.42 %. As shown in Fig 5.13, titrable acidity in fruits of the check variety 'Indu' was significantly lower than all *neikumbalam* accessions (0.18 %) and was on par with BH 11 (0.23 %). The fruits of *neikumbalam* type BH 12 recorded a significantly higher acidity (0.62 %) among all accessions and it was on par with BH 6 (0.57 %).

The total mineral content of fruits among the accessions was significantly highest in BH 4 (415 mg/ 100 g). Total mineral content in the check variety 'Indu' was 347 g/ 100g. The least value for total mineral content was recorded in BH 3 (322 mg/ 100 g). As seen in Fig 5.14, the mean value of mineral content in fruits of *neikumbalam* accessions was higher than mineral content in fruits of 'Indu'.

In an earlier study, Mishra *et al.* (2016) have reported the presence of minerals like calcium, potassium and zinc in ash gourd fruits. Pandey *et al.* (2015) observed the presence of mineral elements with high level of K and low level of Na in ash gourd fruits. Dobre (2013) had reported that the amount of total ash in ash gourd fruit is within the range of 0.3 to 0.5 % of the fruit pulp.

The *neikumbalam* type BH 4 recorded significantly highest total free amino acid content (109.6 mg/ 100 g) than in other accessions and the check variety 'Indu' as seen in Fig 5.15. Total free amino acid content in fruits of the check variety 'Indu' was 66.7 mg/ 100 g. It was least in the fruits of accessions BH 6 and BH 7 (53.6 mg/ 100 g). The mean value for total free amino acid content in neikumbalam fruits was higher than amino acid content in fruits of 'Indu', the check variety.

Amino acid composition of different parts of ash gourd fruit (pulp, seed and skin) were studied by Mingyu *et al.* (1995). Results showed that total protein and free amino acids were present in high amounts in seed and lowest in amount in the pulp. In Ayurvedic literature, *kushmanda* is considered as a *medhya* (rejuvenating) drug. The high amount of free amino acids observed in the present study is an indication of the rejuvenating property of *neikumbalam* fruits.

The protein content in the *neikumbalam* fruits varied from 198.50 mg/100g to 343 mg/ 100 g. Protein content in the check variety 'Indu' (440 mg/ 100 g) was significantly higher than all *neikumbalam* accessions as seen from Fig 5.16.

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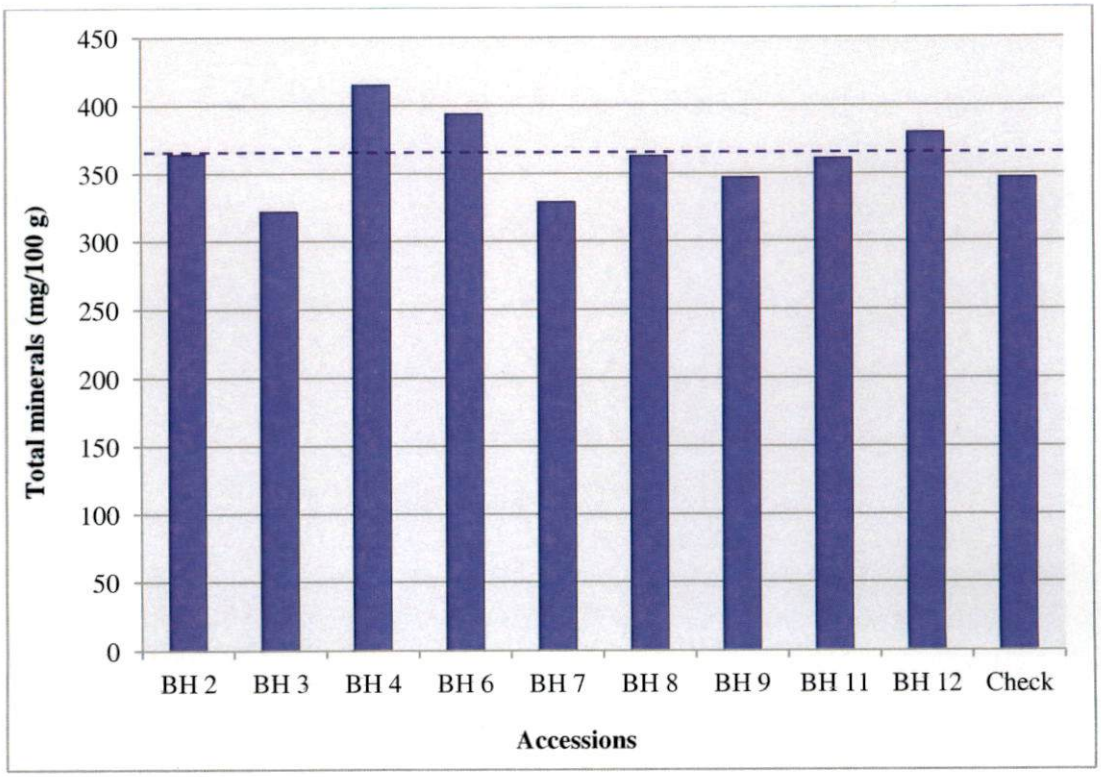

Fig 5.14 Total mineral content in *neikumbalam* fruits

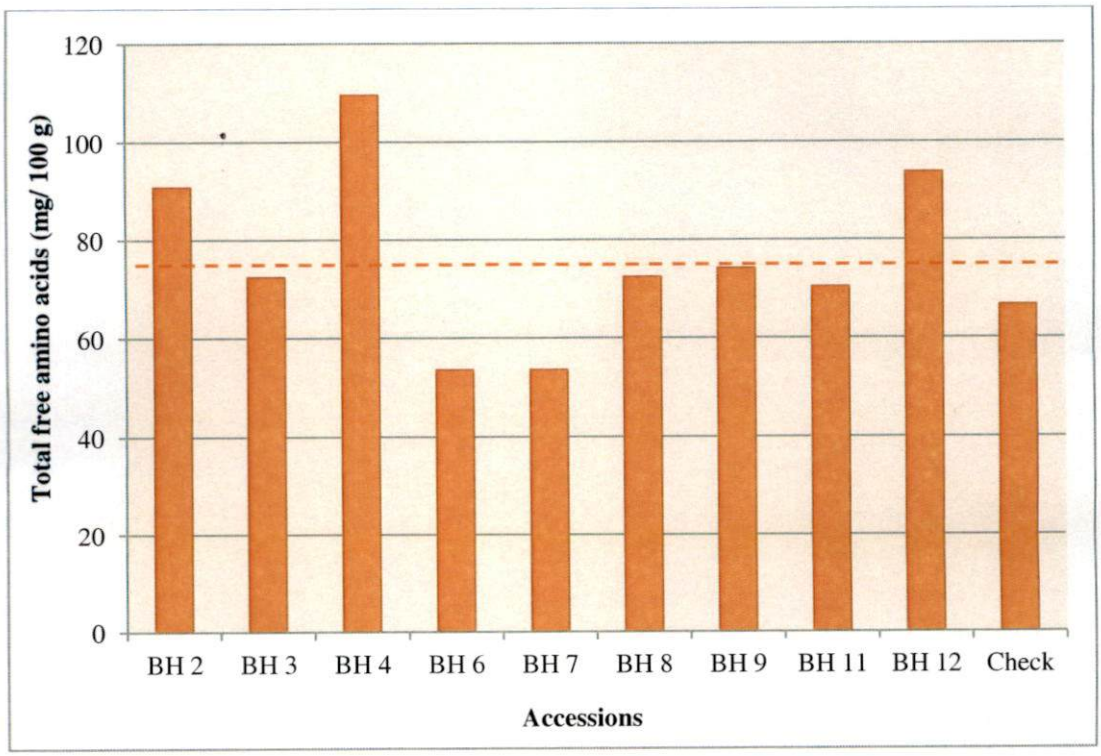

Fig 5.15 Total free amino acid content in *neikumbalam* fruits

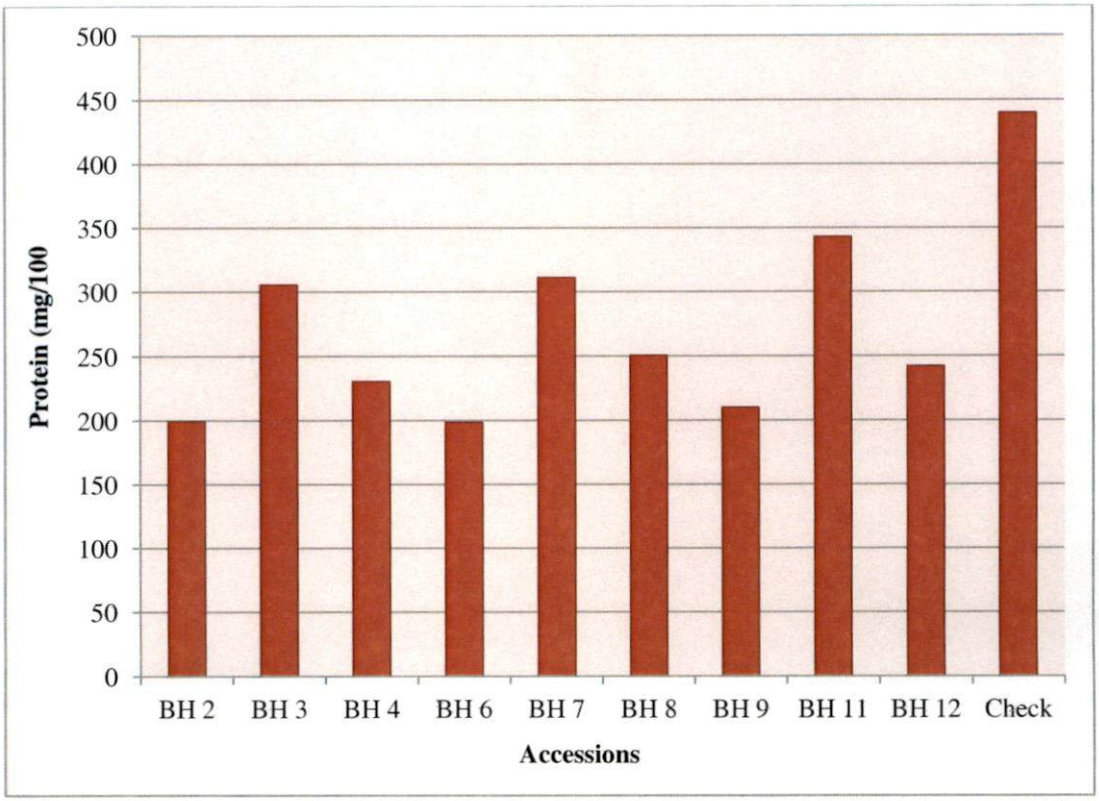

Fig 5.16 Protein content in *neikumbalam* fruits

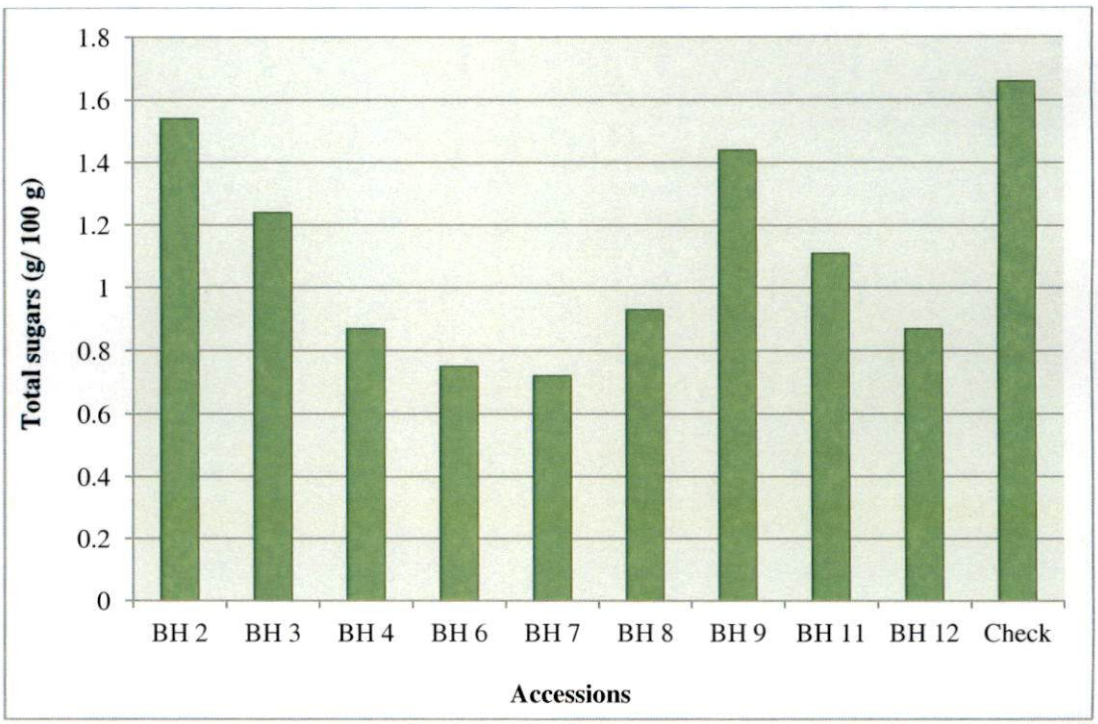

Fig 5.17 Total sugar content in *neikumbalam* fruits

The protein content in Indu and *vaidyakumbalam* as reported in a study by Nagaraju *et al.* (2016) was 391.94 mg/100g and 378.08 mg/100g respectively.

Total sugar content also was significantly higher in fruits of the check variety 'Indu' (1.66 g/ 100 g) than fruits of *neikumbalam* accessions as shown in Fig 5.17. It was highest in BH 2 (1.54 g/ 100 g) and least in BH 7 (0.72 g/ 100 g).

The starch content of fruits among the *neikumbalam* accessions showed a wide variation with a mean value of 0.4 %. Starch content in the type BH 6 (0.73 %) was significantly higher than other accessions. The fruits of the check variety 'Indu' had a starch content of 0.23 %. It was lowest in BH 4 (0.02 %).

Total phenol content in *neikumbalam* fruits was found to vary from 76 mg/ 100 g to 136 mg/ 100 g. As seen in Fig 5.18, phenol content was significantly highest in the *neikumbalam* type BH 8 (136 mg/ 100 g) followed by the check variety 'Indu' (112 mg/ 100 g). Tannin content in the *neikumbalam* type BH 6 (960 mg/ 100 g) was significantly higher than other accessions as seen in Fig 5.19. Tannin content in fruits of 'Indu' was 920 mg/ 100 g. The lowest tannin content was observed in fruits of BH 7 (574 mg/ 100 g). Phenols and tannins are important phytoconstituents which contribute to the antioxidant property. Badhani *et al.* (2013) have reported the presence of phenolic compounds and tannins as major constituents of ash gourd fruits. So, higher value of these parameters recorded in the present study may be a contributing factor for the reported medicinal properties of *neikumbalam*.

The IC 50 value for the free radical scavenging activity of the fruit extracts among the *neikumbalam* accessions ranged from 1.315 to 2.595. As shown in Fig 5.20, IC 50 value of the fruit extract of the check variety 'Indu' (1.109) was significantly lower than all other accessions.

According to Hatano *et al.* (1989), phenolic compounds contribute directly to antioxidative action. High correlation has been observed in antioxidant capacities and phenolic contents. Huang *et al.* (2004) and Roy *et al.* (2007) after conducting *in vitro* and *in vivo* studies on ash gourd fruit reported that its juice and extract has antioxidant activity especially on human tissues like liver and brain.

113

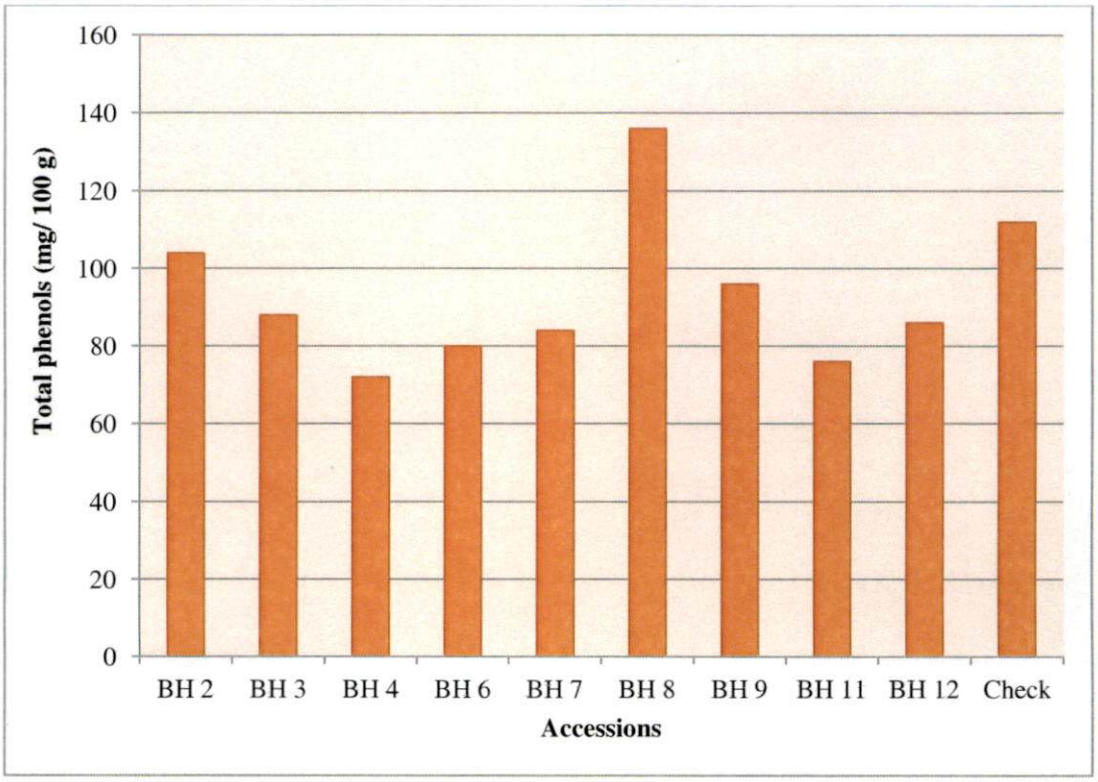

Fig 5.18 Total phenol content in *neikumbalam* fruits

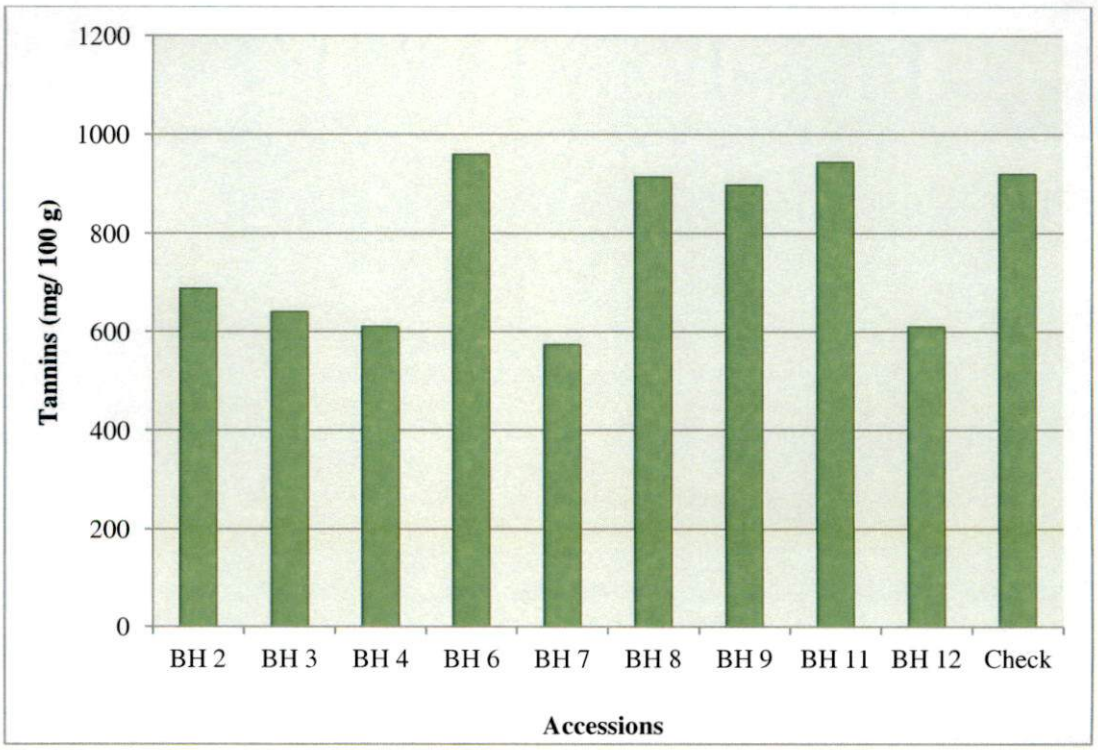

Fig 5.19 Total tannin content in *neikumbalam* fruits

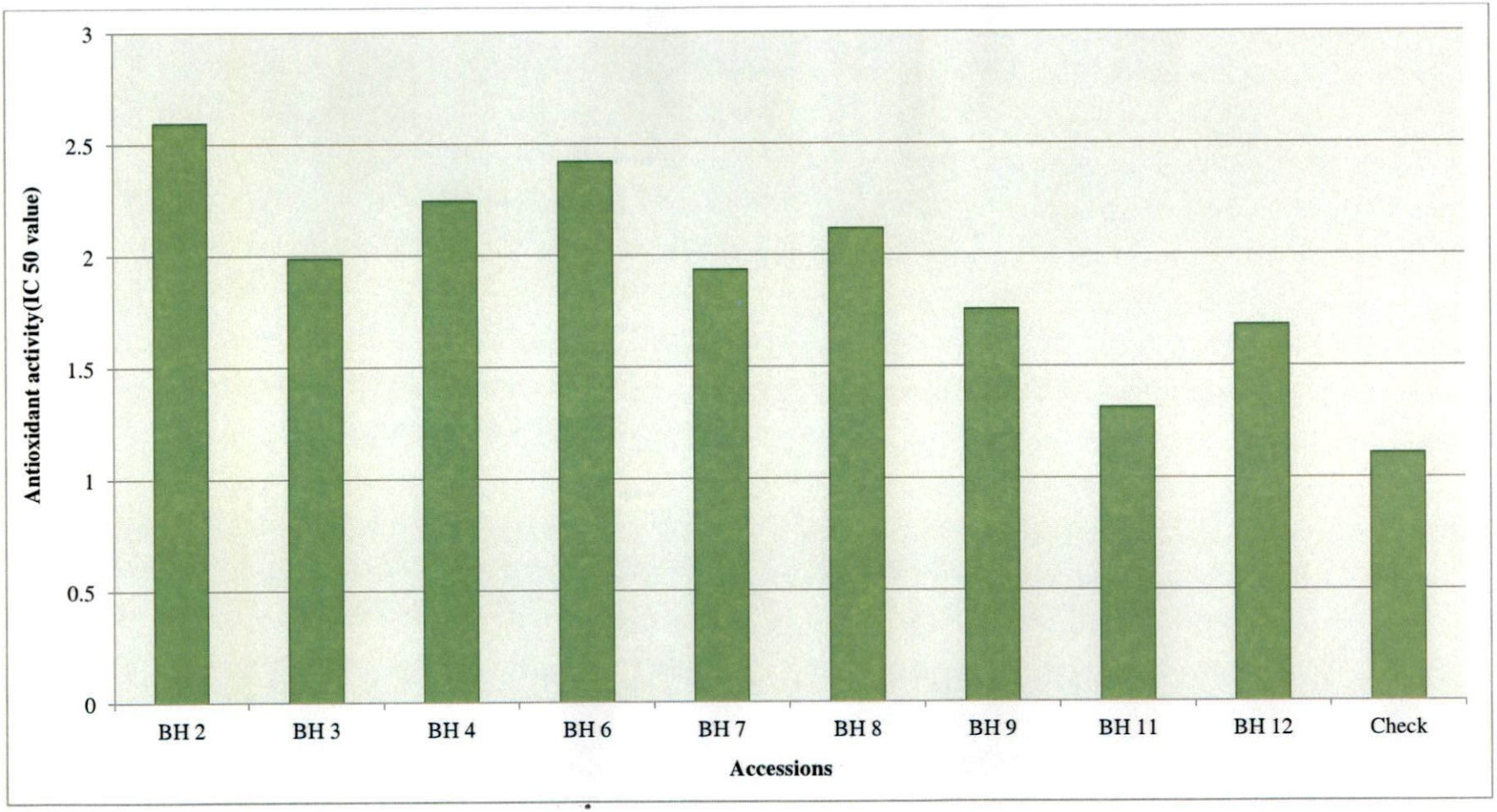

Fig 5.20 Antioxidant activity in *neikumbalam* fruits

The continuous formation of free radicals in human body can be controlled naturally by different beneficial compounds known as anti oxidants. In the current study, the ethanolic extract of *neikumbalam* fruits exhibited significantly high antioxidant property as indicated by the IC 50 value. This finding is in support of the reported medicinal use of ash gourd in treating diseases caused by free radicals and oxidative stress.

Results of the present study indicate that this unique type of ash gourd is morphologically different from the vegetable type ash gourd in growth pattern, flowering nature, fruiting and yield characters. *Neikumbalam* which is considered as a *medhya* (rejuvenating) drug contained higher amount of free amino acids and minerals and had high antioxidant activity. This might be one of the factors responsible for its reported medicinal properties.

Summary

6. SUMMARY

The study entitled "Evaluation of *neikumbalam* (*Benincasa hispida* (Thunb.) Cogn.) collections for yield and quality was carried out in the Department of Plantation Crops and Spices at College of Horticulture, Vellanikkara with the objectives to collect *neikumbalam* types from Kerala and to evaluate the collected types for yield and medicinal quality. Sixteen accessions of *neikumbalam* collected from different locations in Southern, Central and Northern Kerala were evaluated along with a vegetable ash gourd variety, 'Indu' used as check for various morphological, flowering, yield, fruit, seed and biochemical characters. The salient findings of the study are summarized here.

The germination percentage in 'Indu' was higher than all *neikumbalam* accessions. The accession BH 9 recorded highest germination percentage among the *neikumbalam* types.

The check variety 'Indu' recorded significantly highest vine length at all four growth stages, *viz.* pre flowering, flowering, fruiting and harvest stages, compared to the *neikumbalam* accessions. Among the *neikumbalam* types, highest vine length was recorded in BH 11 at all growth stages. The number of primary branches was significantly higher in the check variety 'Indu' than the *neikumbalam* types at all four stages of the crop. Among the accessions, number of primary branches was highest in BH 7 at pre flowering and harvest stages, and in BH 11 at fruiting and harvest stages. Number of leaves was significantly highest in the check variety 'Indu' during the first three growth stages, *viz.* pre-flowering, flowering and fruiting stages and highest in the *neikumbalam* type BH 11 at the harvest stage. Among the accessions, BH 11 recorded highest number of leaves at all stages. Leaves of vegetable ash gourd were larger in size than those of medicinal ash gourd. Only a single *neikumbalam* accession (BH 11) recorded a slightly higher leaf area than the check variety Indu. The medicinal ash gourd accessions were less vigorous in growth, producing lower number of branches and leaves and smaller leaves when compared to its vegetable counterpart 'Indu'.

118

Ash gourd is a monoecious crop, producing male and female flowers separately on the same plant. The *neikumbalam* accession BH 16 took the least number of days to first male flower (59 days). Male flowers in the accessions BH 13, BH 14 and BH 15 also opened earlier than male flowers in Indu, the check (77.42 days). The accession BH 13 took the least number of days to first female flower opening (55.62 days). The accessions BH 1, BH 6, BH 12, 14, BH 15 and BH 16 also reported earlier opening of female flower than in 'Indu' (87.17 days). The accession BH 7 recorded highest number of days for both first male flower and first female flower opening. In general, in ash gourd, male flowers appear first and female flowers later. But, it was observed that opening of first female flower took place earlier than first male flower in the types BH 13, BH 14, BH 15 and BH 16, whereas in all other accessions, male flowers opened earlier.

The *neikumbalam* type BH 16 recorded significantly lowest number of nodes to first male flower (7 nodes). The highest number of nodes to first male flower was recorded in BH 11 (18 nodes). The first male flower was produced at a lower node than in the check variety Indu (11.88) in the accessions BH 16, BH 6, BH 12, BH 3, BH 7, BH 1, BH 13, BH 2 and BH 8. The accession BH 13 produced the first female flower at the lowest node (4.75). The accessions BH 13, BH 14, BH 15 and BH 16 produced female flowers at lower nodes than other accessions and also at lower nodes than male flowers. The check variety 'Indu' recorded significantly highest number of nodes to first female flower than all *neikumbalam* types (24.79 nodes).

The number of male flowers was significantly highest in the check variety 'Indu' (42.46). Highest number of male flowers among *neikumbalam* types was observed in BH 11 (25.75). The least number of male flowers was observed in BH 16 (11.5). Two accessions, BH 2 and BH 6 produced more female flowers than 'Indu' (4.79). BH 2 recorded significantly highest number of female flowers. Sex ratio is an important yield contributing parameter in any monoecious cucurbit. Lower sex ratio indicates highest number of female flowers and lower number of male flowers which in turn is always associated with high yield. Sex ratio in the check variety 'Indu' was found to be significantly higher (9.37) than all *neikumbalam* accessions. The lowest sex ratio of 3.5 was recorded in BH 2.

119

With respect to yield characters, fruit set per cent showed wide variation among the accessions. The type BH 14 recorded significantly highest fruit set percent (75 %) than all other *neikumbalam* types and the check variety 'Indu' (51.92 %). No fruit set was observed in BH 13. The medicinal ash gourd accession BH 7 produced highest number of fruits per plant (2.84) than other accessions and the check variety 'Indu' (2.54). This character assumes importance as yield depends on the number of fruits per plant. However, due to low single fruit weight (1250 g in BH 7), the yield per plant was less in medicinal ash gourd accessions than 'Indu' in which the individual fruit weight was significantly high (2380 g). Fruit yield per plant for *neikumbalam* accessions ranged from 0.46 kg (BH 16) to 3.48 kg (BH 7). The check variety 'Indu' recorded a significantly higher yield of 6.13 kg per plant than all *neikumbalam* types.

There was variation in the number of days taken for fruit maturity and crop duration among the medicinal ash gourd accessions. Days taken for fruit maturity among the accessions ranged from 33.5 days (BH 10) to 45.12 days (BH 8). The check variety 'Indu' took 38.23 days for the same. Crop duration recorded in 'Indu' was 136.88 days. The crop duration ranged from 102.66 days (BH 16) to 153 days (BH 9) among the medicinal ash gourd accessions.

Variability was observed in all the qualitative fruit characters studied. Oblong, spherical and conical shaped fruits were observed. Oblong fruits were observed in seven accessions (BH 1, BH 2, BH 3, BH 6, BH 7, BH 8 and BH 12), spherical fruits in three accessions (BH 4, BH 5 and BH 11) and conical fruits in two accessions (BH 9 and BH 10). The check variety 'Indu' also produced oblong fruits. At edible or immature stage, the fruits were covered with pointed whitish hair which disappeared gradually with maturity and a waxy layer was formed on the skin. The intensity of hairiness and waxiness varied among the accessions and they were categorized as low, medium and high. Hairiness was low in the check variety 'Indu' and majority of the *neikumbalam* accessions (BH 1, BH 3, BH 6, BH 7, BH 8, BH 9, BH 10 and BH 11), medium in two accessions (BH 4 and BH 5) and high in two other accessions (BH 2 and BH 12). Waxiness over the fruit surface was of medium intensity in majority of the accessions (BH 1, BH 2, BH 3, BH 8, BH 9 and BH 12)

120

and in the check variety 'Indu', low in the accessions BH 6 and BH 10 and high in the accessions BH 4, BH 5, BH 7 and BH 11. There was variation in rind colour also among the accessions, *viz.* dark green, bright green, yellowish green and light green. The rind colour was dark green in five accessions (BH 1, BH 3, BH 6, BH 7 and BH 8), bright green in two accessions (BH 2 and BH 11), yellowish green in one accession (BH 4) and light green in four accessions (BH 5, BH 9, BH 10 and BH 12) and the check variety 'Indu'. The keeping quality of fruits ranged from six weeks (BH 3, BH 9 and BH 10) to 11 weeks (BH 4 and BH 5) under ambient conditions. The check variety 'Indu' had a keeping quality of seven weeks.

The fruits of medicinal ash gourd were significantly smaller in size than fruits of Indu. Fruit length showed considerable variation among the accessions. It varied from 9.8 cm (BH 12) to 24 cm (BH 1). The check variety 'Indu' recorded significantly highest fruit length than all *neikumbalam* accessions (29.20 cm). Fruit diameter in the check variety 'Indu' (14.8 cm) was also significantly higher than all *neikumbalam* accessions, among which it ranged from 7.9 cm (BH 12) to 13.6 cm (BH 5). The fruits of *neikumbalam* were lesser in weight than fruits of Indu. Fruit weight among the medicinal ash gourd accessions varied from 349 g (BH 12) to 1250 g (BH 7). Average fruit weight was significantly higher in the check variety 'Indu' (2380 g). Rind thickness was significantly lower in the *neikumbalam* accessions which ranged from 1.33 mm (BH 4) to 2.67 mm (BH 3). Rind thickness in Indu was 3.33 mm. The *neikumbalam* fruits also recorded significantly less flesh thickness and major part of the fruit volume was occupied by seeds. Flesh thickness in the check variety 'Indu' (32.67 mm) was significantly higher than all accessions. It was least in BH 12 (12 mm) and highest in BH 7 (23.33 mm).

Various seed characters were recorded after extraction of seed from the fruits. Seeds of *neikumbalam* were small compared to Indu, the check. Seed length in the check variety 'Indu' (12 mm) was higher than *neikumbalam* accessions. It ranged from 11.83 cm (BH 6) to 9.17 cm (BH 11) among the accessions. Significantly highest seed breadth was recorded in BH 7 (7 mm) and it was comparable to the seed breadth in the check variety 'Indu' (6.83 mm). Seed breadth was lowest in BH 10 (4.5 mm). However, most of the *neikumbalam* accessions

121

recorded more number of seeds per fruit than 'Indu' (523 seeds). The *neikumbalam* type BH 7 recorded significantly highest number of seeds (739).

Weight of seed coat, seed kernel and hundred seed weight were significantly less in *neikumbalam* accessions. Seed coat weight in the check variety 'Indu' (36.96 mg) was significantly higher than *neikumbalam* types. Seed coat weight among the accessions ranged from 17.96 mg (BH 12) to 32.18 mg (BH 7). Weight of seed kernel in 'Indu' was 31.62 mg and it ranged from 15.78 mg (BH 5) to 26.78 mg (BH 7) among the accessions. The hundred seed weight of freshly extracted seeds in the check variety 'Indu' was 7.23 g. Among the accessions, hundred seed weight (fresh) was highest in BH 7 (6.02 g) and least in BH 3 (3.61 g). Hundred seed weight (dry) also followed the same trend and it was significantly highest in the check variety 'Indu' (6.67 g) than *neikumbalam* accessions. Among the accessions, seed weight after drying was highest in BH 7 (5.84 g) and lowest in BH 12 (3.34 g).

Seed viability was tested by Tetrazolium test. Seeds of all accessions and the check variety 'Indu' recorded more than 96 % viability after two months, the highest value recorded in BH 13 (99.33 %). The *neikumbalam* type BH 3 recorded significantly lowest (46.67 %) seed viability. Kernel oil was highest in the *neikumbalam* type BH 6 (1.07 %) and lowest in BH 2 (0.48 %). The check variety 'Indu' recorded a kernel oil content of 0.98 %.

Ethanol extract of the fruit pulp of medicinal as well as vegetable ash gourd were screened for phytochemicals before subjecting to biochemical estimation, which showed that both types of ash gourd fruits contained phytochemicals *viz.* tannins, starch, proteins, amino acids, sugars, phenols, flavonoids and glycosides. Steroids and saponins were not detected in the *neikumbalam* fruit extract.

Most of the biochemical characters showed variation among the accessions. pH of fruit juice in the *neikumbalam* accession BH 7 (5.8) was significantly higher than other accessions. pH of fruit juice in the check variety 'Indu' was 5.5 and the lowest pH was recorded in the *neikumbalam* type BH 11 (5.03). Acidity of fruits of *neikumbalam* was significantly higher than the vegetable ash gourd (0.18 %). Acidity among the accessions ranged from 0.23 % (BH 11) to 0.62 % (BH 12).

122

The starch content of fruits among the *neikumbalam* accessions showed a wide variation. Starch content in the type BH 6 (0.73 %) was significantly higher than other accessions. The fruits of the check variety 'Indu' had a starch content of 0.23 %. Starch content was lowest in BH 4 (0.02 %).

Protein content and total sugar content in the *neikumbalam* accessions were significantly lower than that in the check variety 'Indu'. The protein content in the *neikumbalam* fruits varied from 198.5 mg/100g (BH 6) to 343 mg/ 100 g (BH 11). Protein content in the check 'Indu' was 440 mg/ 100 g. Total sugar content among fruits of neikumbalam types was highest in BH 2 (1.54 g/ 100 g) and least in BH 7 (0.72 g/ 100 g). Total sugar content in fruits of the check variety 'Indu' (1.66 g/ 100 g) was significantly higher.

The mean value for total amino acid content in fruits of *neikumbalam* accessions was 76.76 mg/ 100 g which was higher than that in the check variety 'Indu' (66.7 mg/ 100 g). The *neikumbalam* type BH 4 recorded significantly highest total amino acid content (109.6 mg/ 100 g). It was least in the fruits of accessions BH 6 and BH 7 (53.6 mg/ 100 g). In Ayurvedic literature, *kushmanda* is considered as a *medhya* (rejuvenating) drug. The high amount of free amino acids observed in the present study is an indication of the rejuvenating property of *neikumbalam* fruits.

The total mineral content of fruits among the accessions was significantly highest in BH 4 (415 mg/ 100 g). Total mineral content in the check variety 'Indu' was 347 g/ 100g which was lesser than the mean value among the accessions (363.89 mg/ 100g).

Total phenol content and tannin content showed significant variation among the accessions. Total phenol content in *neikumbalam* fruits ranged from 76 mg/ 100 g (BH 11) to 136 mg/ 100 g (BH 8). The check variety 'Indu' had a phenol content of 112 mg/ 100 g. Tannin content in the neikumbalam type BH 6 (960 mg/ 100 g) was significantly higher than other accessions and the lowest tannin content was observed in fruits of BH 7 (574 mg/ 100 g). Tannin content in fruits of 'Indu' was 920 mg/ 100 g. Phenols and tannins are important phytoconstituents which contribute to the antioxidant property. Higher value of these parameters observed in

123

the present study could be one of the contributing factors for the the medicinal value of *neikumbalam* fruits.

Antioxidant property was observed in all the accessions including the check variety 'Indu'. The IC 50 value for the free radical scavenging activity of the ethanolic extract of *neikumbalam* fruits ranged from 1.315 (BH 11) to 2.595 (BH 2). This was significantly higher than the IC 50 value of the fruit extract of the check variety 'Indu' (1.109). These values indicate the higher antioxidant property of *neikumbalam* fruits. This finding is in support of the reported medicinal use of ash gourd in treating diseases caused by free radicals and oxidative stress.

Results of the present study indicate that this unique type of ash gourd is morphologically different from the vegetable type ash gourd in growth pattern, flowering nature, fruiting and yield characters. *Neikumbalam* which is considered as a ***medhya*** (rejuvenating) drug contained higher amount of free amino acids and minerals and had high antioxidant activity. This might be one of the factors responsible for its reported medicinal properties.

References

7. REFERENCES

Afroze, F. 2006. Genetic divergence in ash gourd (*Benincasa hispida* Thunb.), MSc (Genetics and plant breeding) thesis, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh, 70p.

Agarwal, V.S. 1997. *Drug Plants of India.* Kalyani Publishers, New Delhi, 217p.

Ahmed, M.S., Halim. G. M. A., Mollash, M. S. and Choudhury, S. S. 1995. Genetic variability and correlation studies in some watermelon cultivars. *Bangladesh J. Agric. Sci.* **22** (1): 99-105.

Aquilah, N. M. Z., Anwar, F., Hamid, A. A., and Saari, N. 2011. Kundur [*Benincasa hispida* (Thunb.) Cogn.]: A potential source for valuable nutrients and functional foods. *Food Res. Int.* **44**: 2368-2376.

Arora, S. K., Pandita, M. L., Pratap, P. S. and Sidhu, A. S. 1983. Variability and correlation studies in sponge gourd (*Luffa cylindrical* Roem.). *Haryana Agric. Univ. J. Res.* **13** (1): 146-149.

Asolkar, L. V., Kakkar, K. K., and Chakre, O. I. 1992. *Glossary of Indian Medicinal Plants with Active Principles* Part-I. Publication and Information Directorate (CSIR),New Delhi, India, 371p.

Asolkar, L. V., Kakkar, K. K., and Chakre, O. I. 2000. *Glossary of Indian Medicinal Plants with Active Principles Part I (A-K).* National Institute of Science Communication, New Delhi, 414p.

Badhani, S., Kainth, A., Kabra, A. and Parashar, B. 2013. Evaluation of antioxidant activity of *Benincasa hispida* fruit extracts. *Am. J. Pharmacol. Technol. Res.* **3** (2): 335-345.

Bairwa, P. L. 2016. Genetic divergence analysis in indigenous germplasm of ash gourd [*Benincasa hispida* (Thunb.) Cogn.], MSc (Hort) thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur, 113p.

126

Braca, A., Nunziantina, D. T., Lorenzo D. B., Cosimo, P., Matteo, P. and Ivano, M. 2001. Antioxidant principles from *Bauhinia tarapotensis*. *J. Nat. Product* **64**: 892-895.

Chandrakumar, N. L. 2006. Genetics of growth, yield and quality parameters in pumpkin (*Cucurbita moschata* Dutch. ex Poir.). M.Sc. thesis, University of Agricultural Science, Dharwad.

Chauhan, D. V. S. 1989. *Vegetables production in India*. Ramprasad and Sons, Agra, India, 152p.

Chhonkar, V. S. 1977. Genotypic and phenotypic variability in water melon (*Citrullus lanatus* Thunb. Mansf.). *Bangladesh Hortic.* **5** (2): 7-14.

Chigwe, C. F. B. 1991. *Evaluation of Malawi pumpkin (Cucurbita moschata Duch. ex Poir.) Germplasm collection*. Lilongawe, Malawi, 35p.

Choi, H. Y., Park, Y. K., Kim, D. I., Kim, Y. H., Yoon, G. B., Noh, Y. G. 2001. *Donguibogam*. Yeogang Press, Seoul, pp 374–402.

Chowdhury, B. 1967. *Vegetables*. National Book Trust, New Delhi, India. pp 157-158.

Clevengers, J. F. 1982. Apparatus for determination of volatile oil. *J. Am. Pharmacol. Assoc.* **17**:346-348.

Dahiya, M. S., Pandita, M. L. and Vashistha, R. N. 1989. Genetic variability and heritability studies on round melon (*Para citrullus*). *Haryana J. Hortic. Sci.* **18** (3): 253-256.

Dewan, M. M. R., Mondal, S., Islam, M. S., Mukul, M. H. R., and Hossen, M. A. 2014. Study on correlation and path analysis of the yield contributing characters of different ash gourd accessions. *Eco-friendly Agric. J.* **7** (1): 1-5.

Dewan, M. M. R., Rabbani, M. G., Naher, U. A., Pramanik, S., and Quais, M. K. 2013. Genetic diversity of ash gourd (*Benincasa hispida*) genotypes. *Bangladesh J. Plant Breed. Genet.* **26** (2): 1-8.

127

Dobre, C. 2013. Research regarding the cultivation of *Benincasa hispida* in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural development. **13** (2): 119-122.

Doijode, S. D. and Sulladmath, U. V. 1986. Genetic variability and correlation studies in pumpkin (*Cucurbita moschata* Poir.). *Mysore J. Agric. Sci.* 20 (1): 59-61.

Gangopadhyay, K. K., Kumar, G., Meena, B.L., and Bisht, I. S. 2008. Genetic diversity studies in ash gourd (*Benincasa hispida* (Thunb.) Cogn.) from Northern India. *J. Plant Genet. Resour.* **21**(3): 206-212.

Geneve, R. L. 1998. Seed dormancy in commercial vegetable and flower species. *Seed Technol.* **20** :236-250.

George, T. E. 1981. Biometrical studies in ashgourd (*Benincasa hispida* (Thunb.) Cogn.) M.Sc. (Ag) Thesis, KAU, Thrissur, 96p.

Gill, B. S. and Kumar, J. C. 1986. Variability in genetic stock and heritable components in water melon. *J. Res. Punjab Agric. Univ.* **23** (4): 583-588.

Gopalakrishnan, R. 1957. Medicinal ash-gourd (A new variety). *Madras Agric. J.* **44**: 345- 346.

Gopalakrishnan, T. R., Gopalakrishnan, P. K. and Peter, K. V. 1987. Evaluation of a few selected lines of pumpkin for local adaptability. *Agric. Res. J. Kerala.* **25** (1): 121.

Gopalan, C., Ramasastri, B. V. and Balasubramanian, S. C. 1997. *Nutritive Value of Indian Foods*. National Institute of Nutrition (ICMR), Hyderabad (India).

Grover, J. K. and Rathi, S. S. 1994. Anti-inflammatory activity of fresh juice of *Benincasa hispida. Ind. J. Pharmacol.* 26 (1): 66.

Grover, J. K., Adiga, G., Vats, V. and Rathi, S. S. 2001. Extracts of *Benincasa hispida* prevent development of experimental ulcers. *J. Ethnopharmacol.* 78 (3): 159-164.

Grubben, G. J. H. 2004. *Benincasa hispida* (Thunb. ex Murray) Cogn. Grubben, G. J. H. and Denton, O. A. (eds). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands, 667p.

Hamid, M. M., Sana, M. C., Begum, R. A., Hussain, S. M. M. 1989. Physiomorphology and yield of different ashgourd (*Benincasa hispida* Cogn.) lines. *Bangladesh J. Agric.* **14** (1): 51- 55.

Handa, S. S. and Kapoor, V. K. 1999. *Pharmacognosy*. Vallabh Prakashan, New Delhi, 113p.

Harbone, J. B. 1999. Phytochemical methods, Chapman and Hall, London, pp 60-66.

Hartmann, H. T., Kester, D. E., Davies, F. T. and Geneve, R. L. 1997. *Plant Propagation: Principles and Practices.* Prentice-Hall. Inc. Englewood Cliffs, New Jersey, 770p.

Hatano T., Edamatsu, R., Hiramatsu, M., Mori, A., Fujita, Y., Yasuhara, D. 1989. Effects of interaction of tannins with co-existing substances. VI. Effects of tannins and related polyphenols on superoxide anion radical and on DPPH radical. *Chem. Pharma. Bull.* **37**: 2016-2021.

Hedge, J. E. and Hofreiter, B. T. 1962. *Methods in Carbohydrate Chemistry.* Academic Press, New York, 201p.

Huang, H. Y., Huang, J. J., Tso, T. K., Tsai, Y. C. and Chang, C. K. 2004. Antioxidant and angiotensin converting enzyme inhibition capacities of various parts of *Benincasa hispida* (wax gourd). *Nahrung* **48** (3): 230-233.

Indira, P. and Peter, K.V. 1987. *Underexploited Tropical Vegetables.* Kerala Agricultural University, Thrissur, 68p.

Kalloo, G. and Bergh, O. 1993. *Genetic Improvement of Vegetable Crops*. Pergamon Press, United Kingdom, pp. 235-238.

Katayal, S. L. 1985. *Vegetable Growing in India*. Oxford and IBH Publishing Co., New Delhi, India, pp 92-93.

Kokate, C. K. 2000. *Practical Pharmacognosy*. Vallabh Prakashan, Delhi, pp 107-111.

Kumar, D. A. and Ramu, P. 2002. Effect of methanolic extract of *Benincasa hispida* against histamine and acetylcholine induced bronchospasm in guinea pigs. *Indian J. Pharmacol.* **34**: 365–366.

Kumar, A. and Vimalavathini, R. 2004. Possible anorectic effect of methanol extract of *Benincasa hispida* (Thunb.) Cogn. fruit. *Indian J. Pharmacol.* **36**: 348–350.

Kumaran, S. S., Natarajan, S. and Thamburaj, S. 1998. Correlation and path analysis studies in pumpkin (*Cucurbita moschata* Poir.). *S. Indian Hortic.* **46** (3-6): 138-142.

Latif, M. A., Ahmed, N. U. and Alam, M. M. 2008. Genetic variability and path analysis in ash gourd (*Benincasa hispida*). *J. Sher-e-Bangla Agric. Univ.* **2** (1):80-87.

Lee, K. H., Choi, H. R. and Kim, C. H. 2005. Anti-angiogenic effect of the seed extract of *Benincasa hispida* Cogniaux. *J. Ethnopharmacol.* **97**: 509–513.

Mandal, J., Sirohi, P. S. and Behera, T. K. 2002. Genetical studies on flowering and fruit maturity in ashgourd. *Orissa J. Hort.* **30** (1): 40- 42.

Mangal, J. L., Dixit, I., Pandita, M. L. and Sidhu, A. S. 1983. Genetic variability and correlation studies in bitter gourd (*Momordica charantia* L.). *Indian J. Hortic.* **40** (3-4): 94-99.

Mannan, M. A. 1992. Studies on variability, genetic parameters and correlation in bitter gourd. M.Sc. (Ag.) thesis, Dept. of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Marr, K. L., Xia, Y. M. and Bhattarai, N. K. 2007. Allozymic, morphological, phenological, linguistic, plant use, and nutritional data of *Benincasa hispida* (Cucurbitaceae). *Economic Bot.* **61**: 44–59.

Martin, F. W. 1984. Cucurbit seed as possible oil and protein sources. Echo Technical Note. Retrieved 31 October 2016, from http://www.echotech.org/network/modules.php?name=News&file=article&sid=592

Mathewkutty, T. 1996. *Neikumbalam*. Mathrubhumi Daily, 30 Jan. 1996, p.10.

Mazumder, S., Lerouge, P., Loutelier-Bourhis, C., Azeddine Driouich, A. and Ray, B. 2005. Structural characterization of hemicellulosic polysaccharides from *Benincasa hispida* using specific enzyme hydrolysis, ion exchange chromatography and MALDI-TOF mass spectroscopy. *Carbohydrate Polym.* **59**: 231–238.

Mingyu, D., Mingzhang, L., Qinghong, Y., Weiming, F., Jianxiang, X. and Weiming, X. 1995. A study on *Benincasa hispida* contents effective for protection of kidney. *Jiangsu J. Agric. Sci.* **11**: 46–52.

Mishra, S. S., Singh, S., Rana, S., Gupta, R. K. and Rai, P. 2016. Critical review of *kushmanda* (*Benincasa hispida*)- A potent herb. *Int. J. Pharmacol. Pharma. Res.* **5** (2): 7-15.

Morton, J. F. 1971. The wax gourd, a year-round Florida vegetable with unusual keeping quality. *Proceedings of the Florida State horticultural society.* **84** :104-109.

Nagaraju, K., Saraswathi, T., Bommesh, J. C., Rakesh. S. V., and Rajeev, K. Y. 2016. Study on variability and genetic parameters in ash gourd (*Benincasa hispida* (Thunb.) Cogn.) genotypes. *Int. J. Agric. Sci. Res.* **6** (3): 147-162.

Nielson S. S. 2010. *Phenol-Sulfuric Acid method for total carbohydrates*. Food Science Text Series. pp.47-53.

Package of practices Recommendations: Crops. 2016. Estellita, S., Bonny, B. P., Helen, S. and Suma, A. (eds). Directorate of Extension, Kerala Agricultural University, 393p.

Pandey, A. K., Bhardwaj, D. R., Dubey, R. K., Singh, V., and Pandey, S. 2015. Botany, diversity, utilization and improvement of ash gourd (*Benincasa hispida* Thumb. ex Murray Cogn.) – a review. *Ann. Hortic.* **8** (1): 1- 15.

Pandey, S., Jha, A. and Rai, M. 2009. Screening of advance breeding lines/ cultivars for shelf life and biochemical changes during storage of ash gourd (*Benincasa hispida*). *Acta Hortic.* 806(31): 249-256.

Pandey, S., Kumar, S., Mishra, U., Rai, A., Singh, M., and Rai, M. 2008. Genetic diversity in Indian ash gourd (*Benincasa hispida*) accessions as revealed by quantitative traits and RAPD markers. *Scientia Horticulturae* **118**: 80-86.

Panse, V. G. and Sukhatme, P. V. 1967. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi, pp. 97-151.

Peter, K. V. 1998. *Genetics and Breeding of Vegetables.* Indian Council of Agricultural Research, New Delhi, 133p.

Purseglove, J. W. 1987. *Tropical Crops Dicotyledons*. Longman Scientific and Technical, England, 719p.

Rachchh, M. A. and Jain, S. M. 2008. Gastro protective effect of *Benincasa hispida* fruit extract. *Indian J. Pharmacol.* 40 : 271-275.

Rahman, M. M. 1996. Floral biology of ash gourd. M.Sc. thesis, Department of Genetics and Plant Breeding, Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur, Bangladesh.

Rahman, A. K. M., Das, M., Das, M. K. and Haque, M. M. 1986. Variability, correlation and path co-efficient analysis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Bangladesh J. Agric.* **11** (3): 13-20.

132

Rahman, M. M. S., Dey, S. K. and Wazuddin. 1990. Yield, yield components and plant characters of several bitter gourds, ribbed gourd, bottle gourd and sweet gourd genotypes. *BAU Res. Progress* **4**: 117-127.

Ramesh, M., Gayathri, V., Rao, A. V. N. A., Prabhakar, M. C., and Rao, C. S. 1989. Pharmacological actions of fruit juice of *Benincasa hispida*. *Fitoterpia*, 60(3):241-247.

Rana, T. K, Vashistha, R. N. and Pandita, M. L. 1986. Genetic variability studies in Pumpkin *(Cucurbita moschata* Poir.*). Haryana J. Hortic. Sci.* 15 (1-2): 71

Rana, T. K., Vashistha, R. N. and Pandita, M. L. 1995. Correlation and path coefficient studies in pumpkin (*Cucurbita moschata* Poir). Haryana J. Hortic. Sci. **14** (1-2): 108-113.

Randhawa, K. S., Singh, M. and Arora, S. K. 1982. Floral features to anthesis, dehiscence, stigma receptivity and pollen germination under different media. *Haryana J. Hortic. Sci.* **11** (3-4): 266-269.

Randhawa, K.S., Singh, M., Arora, S.K. and Singh, P. 1983. Varietal variation in physical characters and chemical constituents of ash gourd fruits (*Benincasa hispida* (Thunb.) Cogn.). *PAU J. Res.*, **20**: 251-254.

Rao, K. D. and Sushama, K. 2014. Advanced yield trial on ash gourd (*Benincasa hispida*) under Telengana climatic conditions. *J. Res. PJTSAU* **42** (4): 21-23.

Rashid, M. M. 1993. *Shabjibiggan*. BangIa Academy, Dhaka, Bangladesh. 494p.

Rashid, M. M. 1999. *Vegetable Science* (2nd Edn). Bangla Academy, Dhaka, Bangladesh, pp 352-355.

Raveendran, D. 2003. Evaluation of Neikumbalam in Oil Palm Plantation. M.Sc.(Ag.) Thesis, KAU, Thrissur, 119p.

Retnam, R. K. and Martin, P. 2006. *Ethnomedicinal Plants*. Agrobios India: Jodhpur, pp. 108.

133

Robinson, R. W. and Decker-Walters, D.S. 1997. *Cucurbits*. CAB International, Wallingford, United Kingdom, pp. 226.

Roy, C., Ghosh, T. K., and Guha, D. 2007. The antioxidative role of *Benincasa hispida* on colchicine induced experimental rat model of Alzheimer's disease. *Biogenic Amines* 21: 1–2.

Rubatzky, V. E. and Yamaguchi, M. 1997. *World Vegetables*. Chapman and Hall, New York, U.S.A, 843p.

Sadasivam, S. and Manickam, A. 1996. (2nd Ed). *Biochemical Methods*. New Age International (P) Limited Publishers and Tamil Nadu Agricultural University, Coimbatore, 256p.

Saha, R. R., Mitra, B. N., Hossain, A. E., Jamaluddin, M., and Mosiul Hoque, A. M. M. 1992. Genetic variability, character association and path co-efficient analysis in pumpkin (*Cucurbita moschata* L.) *Bangladesh Hortic*. **20** (1): 59-62.

Sahu, P. K., Sharma, D., and Nair, S. K. 2015. Performance of ash gourd genotypes for earliness and yield under Chattisgarh plains, India. *Plant Arch.* **15** (2): 1157-1160.

Saimbhi, M. S. 1993. Agro-techniques for cucurbits. *Advances in Horticulture: 5. Vegetable Crops: Part I* .Chadha, K. L. and Kalloo, G. (eds). Malhotra Publishing House, New Delhi, pp.401-432.

Sanyal, D. L. M. 1984. *Vegetable Drugs of India*. Bishen Mahendra Pal Singh, Dehra Dun, 397p.

Schandrel, S. H. 1970. *Method in Food Analysis.* Academic Press, New York, 709p.

Seshadri, V. S. 1986. *Cucurbits*. In: Bose, T. K., and Som, M. G. (eds.) *Vegetables crops in India.* 1st edition. Naya Prokash, Calcutta, India. pp 91-164.

Seshadri, V.S. 1993. Cucurbits. *Vegetable Crops.* Second edition. In: Bose, T.K., Som, M.G. and Kabir, J (eds.). Naya Prakash, Calcutta, pp. 40-124.

134

Sew, C. C., Zaini, N. A. M., Anwar, F., Hamid, A. A. and Saari, N. 2010. Nutritional composition and oil fatty acids of Kundur [*Benincasa hispida* (Thunb.) Cogn.] seed. *Pakistan J. Bot.* **42** (5): 3247–3255.

Sharma, N. K. and Bhutani, R. D. 2001. Genetic analysis of yield and fruit number in bitter gourd (*Momordica charantia*). *Haryana J. Hortic. Sci.* **28** (1-2): 88-91.

Simmonds, N. W. 1976. *Evolution of Crop Plants*. Longman, New York. 306 p.

Singhal, P. 2008. Study on morphological and biochemical variations and hybrid breeding in Ash gourd [*Benincasa hispida* (Thunb.) Cogn.]. PhD (Vegetable science) thesis, G. B. Pant University of Agriculture and Technology, 285p.

Sivarajan, V. V. and Balachandran, I. 1994. *Ayurvedic Drugs and Their Plant Sources*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 570p.

Srivastava, V. K. and Srivastava, L. S. 1976. Genetic parameter, correlation coefficients and path coefficient analysis in bitter gourd (*Momordica charantia* L.) *Indian J. Hortic.* **33** (1): 66-70.

Subramanian. K., Sridhar, S., Narayanan, S., Balasubramanian, A. V., and Vijayalakshmi, K. 2013. On farm conservation of Indigenous seeds. Centre for Indian Knowledge Systems, p.7.

Supreeja, A. 2002. The Ash gourd. *Amruth* **4** (2): 31-32.

Swamy, K. R. M., Dutta, O. P., Ramachander, P. R. and Wahi, S. D. 1984. Interrelationships between yield and other quantitative characters in musk melon (*Cucumis melo* L.) *S. Indian Hortic.* **32** (6): 334-339.

Thamburaj, S. and Kamalnathan, S. 1973. Sex expression in *Cucurbita moschata* Poir. and *Benincasa hispida* Cogn.. *Madras Agric. J.* **60** (9-12): 1673-1681.

Tyagi, I. D. 1972. Variability and correlation studies in bottle gourd. *Indian J. Hortic.* **29** (2): 219-222.

Varghese, B. M. 1974. Studies on the cytology of South Indian Cucurbitaceae. Ph.D. Thesis, Kerala Agricultural University, Thiruvananthapuram, 206p.

Vashistha, B. B., Sharma, J. C. and Seshadri, V. S. 1975. A note on the variability and heritability in water melon (*Citrullus lanatus* (Thunb.) Mansf.) *Haryana Agric. Univ. J. Res.* **13** (2): 319-324.

Vashistha, R. N., Partap, P. S. and Pandita, M. L. 1983. Studies on variability and heritability in water melon *Citrullus lunatus* (Thunb.) Mansf.) *Haryana Agric. Univ. J. Res.* **13** (2): 319-324.

Walters, T. W. and Decker-Walters, D. S. 1989. Systematic re-evaluation of *Benincasa hispida* (Cucurbitaceae). *Economic Bot.* **43**: 274–278.

Whistler. W. A. 1990. The other Polynesian gourd. *Pacific Sci.* **44**: 115- 122.

Whitaker, T. W. and Bohn, D. W. 1950. The taxonomy, genetics, production and the uses of the cultivated species of cucurbita. *Economic Bot.* **4**: 52–81.

Wills, R. B. H., Wong, A. W. K., Scriven, F. M., and Greenfield, H. 1984. Nutrient composition of Chinese vegetables. *J. Agric. Food Chem.* **32**: 413–416.

Yang, S. L. and Walters, T. W., 1992. Ethnobotany and the economic role of the cucurbitaceae of China. *Economic Bot.* **46**: 349- 367.

136

EVALUATION OF *NEIKUMBALAM* (*Benincasa hispida* Thunb.) COLLECTIONS FOR YIELD AND QUALITY

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ABSTRACT OF THE THESIS

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ABSTRACT

Ash gourd [*Benincasa hispida* (Thunb.) Cogn.] is a member of the family Cucurbitaceae which is mainly grown for its fruits. *Vaidyakumbalam* or *neikumbalam* is a specific ecotype of ashgourd in Kerala with hard pulp, long keeping quality and size slightly larger than a cricket ball. It is the principal ingredient used in the preparation of the Ayurvedic medicine "*Kooshmanda rasayanam*" and "*poosanilehyam*", a similar preparation made by the Siddha medicine physicians. The availability of this special type of ash gourd is scarce at present. And, not much is known about the morphology and biochemistry of *neikumbalam*. The present study has been undertaken in this context.

The study entitled "Evaluation of *neikumbalam* (*Benincasa hispida* Thunb.) collections for yield and quality" was carried out in the Department of Plantation Crops and Spices during September 2016 to January 2017. Sixteen types of *neikumbalam* (medicinal ash gourd) were collected from different locations in Southern, Central and Northern Kerala. These were evaluated along with a vegetable ash gourd variety 'Indu' used as check, for various morphological, yield, fruit, seed and biochemical characters.

Morphological characters were recorded at four growth stages, *viz.* pre-flowering, flowering, fruiting and harvest. Medicinal ash gourd accessions were less vigorous in growth, producing lower number of branches and leaves and smaller leaves when compared to the vegetable ash gourd variety 'Indu'. Among the *neikumbalam* types, highest vine length was recorded in BH 11 at all the four growth stages (172.85 cm, 212.55 cm, 245.84 cm and 289.46 cm respectively). The leaf area among the accessions ranged from 67.16 cm^2 to 158.8 cm^2.

With respect to flowering, a few of the *neikumbalam* accessions recorded early opening of both male and female flowers. The accessions BH 13, BH 14, BH 15 and BH 16 were early in female flower opening and also produced female flowers at lower nodes than other accessions. The first female flower was produced at a lower node (4.75) in the accession BH 13. Also, all *neikumbalam* accessions had

a sex ratio lesser than the check variety 'Indu' (9.37). The lowest sex ratio was recorded in BH 2 (3.5).

With respect to yield characters, the medicinal ash gourd accession BH 7 produced highest number of fruits per plant than other accessions and the check variety 'Indu'. However, due to low single fruit weight (1250 g in BH 7), the yield per plant was less in medicinal ash gourd than 'Indu' in which the individual fruit weight was significantly high (2380 g). There was variation in the number of days taken for fruit maturity and crop duration among the medicinal ash gourd accessions. The crop duration ranged from 102.66 days to 153 days.

Variability was observed in all the qualitative fruit characters studied. Oblong, spherical and conical shaped fruits were observed. The check variety 'Indu' also produced oblong fruits. The intensity of hairiness and waxiness varied among the accessions and they were categorized as low, medium and high. There was variation in rind colour also among the accessions, *viz.* dark green, bright green, yellowish green and light green. The keeping quality of fruits ranged from 6 weeks to 11 weeks under ambient conditions.

Fruit size exhibited variation among the accessions. The fruits of medicinal ash gourd were significantly smaller in size and lesser in weight (349 to 1250 g) than vegetable ash gourd fruits. Rind thickness was significantly lower in the medicinal ash gourd accessions than the check variety 'Indu'. The *neikumbalam* fruits also recorded significantly less flesh thickness and major part of the fruit volume was occupied by seeds.

Seeds of *neikumbalam* were small compared to Indu, the check. However, most of the *neikumbalam* accessions recorded more number of seeds per fruit (739 seeds in BH 7) than 'Indu' (523 seeds). Weight of seed coat, seed kernel and hundred seed weight were significantly less in *neikumbalam* accessions. Seeds of all accessions and the check variety 'Indu' recorded more than 96 % viability after two months.

Fully mature fruits were screened for various phytochemicals after which they were subjected to biochemical estimation. Most of the biochemical characters showed variation among the accessions. Acidity in fruits of *neikumbalam* was significantly higher than the vegetable ash gourd. Protein content and total sugar content in the *neikumbalam* accessions were significantly lower than that in the check variety 'Indu'. But, the *neikumbalam* collections recorded high amount of free amino acids which is an indication of the rejuvenating property of the fruits. Total phenol content and tannin content showed significant variation among the accessions. But a definite pattern could not be drawn between the *neikumbalam* accessions and the check 'Indu'. The ethanolic extract of *neikumbalam* fruits exhibited significantly high antioxidant activity (1.315 to 2.595) than the check variety 'Indu' (1.109) as indicated by the IC 50 value.

Results of the present study indicate that this unique type of ash gourd is morphologically different from the vegetable type ash gourd in growth pattern, flowering nature, fruiting and yield characters. *Neikumbalam* which is considered as a *medhya* (rejuvenating) drug contained higher amount of free amino acids and had high antioxidant activity. This might be one of the factors responsible for its reported medicinal properties.