INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–6–1062–1065
http://www.ijab.org

Genetic Diversity in Different Morphological Characteristics of Litchi (*Litchi chinensis* Sonn.)

SHAHID KHURSHID, ISHTIAQ AHMAD AND MUHAMMAD AKBAR ANJUM[1]
Department of Horticulture, University College of Agriculture, Bahauddin Zakariya University, Multan – 60800, Pakistan
[1]Corresponding author's e-mail: m.a.anjum@bzu.edu.pk, anjumbzu@yahoo.com

ABSTRACT

In the present work, genetic diversity in morphological characteristics of four cultivar of litchi i.e., Bedana, Bombay, Calcutti and Gola growing under the agro-climatic conditions of Multan was studied. Various characteristics like tree height, canopy spread, tree shape, foliage texture and colour, leaf length, width, shape and orientation, internodal distance, number of leaflets per leaf, number of leaves per flush, flush colour, panicle length, number of anthers and carpels per flower, filament and style size, fruit colour and size were taken into count and variation in the characteristics has been discussed. The cultivars differed in some of the morphological characteristics. The differences were probably due to their genetic make up as well as due to the influence of climatic factors.

Key Words: Cultivars; Growth; Flower; Fruit and leaf characteristics; *Litchi chinensis;* Tree morphology

INTRODUCTION

Litchi *(Litchi chinensis* Sonn.) is an evergreen, subtropical fruit tree belonging to the family Sapindaceae. It is native to South China and South-Eastern Asia, and has been widely cultivated for its prized fruit even before 1766 B.C. (Menzel, 1984). Litchi has been taken to most of the tropical and sub-tropical world in the last 400 years. It is considered as one of the most environmentally sensitive plant and is adopted to areas of the world characterized by warm subtropics and elevated tropics having cool dry winters and warm wet and humid summers (Menzel, 1991). High rainfall and humidity induce good growth in litchi. A dry autumn and winter are important to prevent vegetative growth, which is essential for good flowering (Nakata & Watnabe, 1966). The tree requires adequate moisture from rainfall or irrigation during fruit set and growth.

Litchi cultivars vary greatly in vegetative flushing pattern, flush colour, and flowering ability. There has been wide range of confusion in the names of cultivars due to varying agro-climatic conditions, growth behaviour, fruit colour, shape and size. Thus, the same cultivar may be called by different names at different locations. Genetic diversity in litchi is indicated by a large number of cultivars in China and India, which provides the bases for development of new cultivars. The environment profoundly influenced cultivar characteristics and this may explain why a large number of cultivars are available (Groff, 1921). There are different characteristics, which are used to identify the cultivars. The size and shape of litchi fruit are characteristics for different cultivars (Galan, 1989). The differences in leaf size, shape, length and colour also exist. No systematic attempts for collecting and conservation of litchi germplasm have been made in Pakistan. Only few cultivars are available, which are exotic and perpetuated through vegetative methods of propagation. Literature indicates that different cultivars of litchi differ in their morphological characteristics depending upon the location and climatic conditions. Therefore, the present investigation was initiated to study genetic diversity in various morphological characteristics of different commercially grown cultivars of litchi in Multan region.

MATERIALS AND METHODS

The present investigations were carried out during the year 2002–2003 to describe various morphological characteristics of four cultivars of litchi *(Litchi chinensis* Sonn.) i.e. Bedana, Bombay, Calcutti and Gola available at Hafeez Litchi Farm, Multan. Five trees of each cultivar (about 30 years old), uniform in size and vigour were selected for the study and observations were recorded on the morphological characteristics of each cultivar as mentioned below.

Tree height and canopy spread were recorded by measuring height and width of each experimental tree. Tree shape, foliage texture and colour were recorded by visual observation of the trees. Leaf length, width, shape, orientation, internodal distance, number of leaflets per leaf, number of leaves per flush and flush colour was studied by taking ten leaves and flushes randomly from each cultivar. Panicle length was recorded by measuring ten panicles in each cultivar. Flower colour, number of anthers, number of carpels, filament and style size in each cultivar were observed by taking ten flowers randomly from each cultivar. Fruit colour and size were recorded by taking ten fruits randomly from each cultivar.

Experiment was laid out according to the Randomised Complete Block Design (RCBD). The experiment

comprised of four treatments (cultivars) with five or ten independent observations (replications). Only quantitative data were analysed statistically using Fisher's analysis of variance techniques. Least significant difference (LSD) test at 5% probability level was applied to compare the differences among treatments means (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Tree Characteristics

Tree height. There were no significant differences in tree height of all the four cultivars. It means that all the four cultivars have almost same height (Table I). Although, various studies have indicated significant differences in height of the litchi cultivars (Miao *et al*., 1998; Rai *et al*., 2001), however, in the present study, no significant differences were observed.

Canopy spread. Tree width among the cultivars differed significantly (Table I). The maximum canopy spread or tree width was recorded in Bedana cultivar (9.85 m), which statistically differed from all other cultivars. The minimum tree width was of Bombay cultivar (6.40 m) and that was statistically at per with Calcutti (6.86 m) and Gola cultivars (6.71 m). The difference might be due to their different genetic make up and response to soil and climatic conditions. The growth behaviour of a cultivar may vary in a climate other than it originated. Rai *et al.* (2001) have also reported genetic variation in 13 litchi cultivars for various traits including tree spread and volume.

Tree shape. Bombay and Bedana cultivars had round, dense and symmetrical canopy while Gola had round, less dense, less symmetrical canopy and Calcutti had round, less dense and non-symmetrical canopy (Table I). The differences might be due to the genotypes and their interaction with the prevailing climatic conditions of the area. According to Nakasone and Paull (1998), litchi trees may be broad with low hanging branches or have upright branches and a compact, rounded head, depending upon cultivars.

Foliage colour. Gola and Bedana cultivars had light-green to green foliage colour, while Calcutti had light green and Bombay had dark green foliage (Table I). The foliage colour is a genetic trait and also being used for identification of cultivars. The slight variation could also be due to prevailing environmental condition i.e. sunlight, temperature, humidity, rainfall etc.

Leaf Characteristics

Leaf length. The data on leaf length showed significant results for the cultivars. The maximum leaf length was recorded in Bombay cultivar (15.80 cm), followed by Calcutti cultivar (14.90 cm) and both these cultivars were statistically at par. Minimum leaf length was of Bedana cultivar (11.80 cm) and it was also statistically at par with Gola (12.20 cm) and Calcutti cultivars (Table II). The leaf size is an important varietal character and is also used for cultivar identification (Singh *et al*., 1999).

Leaf width. The data on leaf width also showed significant differences among the cultivars (Table II). The maximum leaf width was of Bombay cultivar (5.10 cm), which statistically differed from all other cultivars. The minimum leaf width was of Bedana cultivar (3.00 cm) and that was statistically at par with Gola cultivar (3.60 cm). As already mentioned, leaf size is a genetic character and may differ from cultivar to cultivar under similar soil and environmental conditions.

Internodal distance. The data of internodal distance showed non-significant results for all the four cultivars (Table II). It indicates that all the four cultivars were alike and there was no significant difference in the internodal distance.

Leaf shape. All the cultivars had oval shaped leaves. However, the leaves of Gola cultivar were moderately shiny and slightly wavy. Bombay cultivar had shiny and wavy curved upward and Bedana cultivar had dull and also wavy curved upward leaves. The leaves of Calcutti cultivar were very shiny and wavy curved downward (Table II). Leaf shape is a genetic character and is of importance in cultivar identification (Singh *et al*., 1999).

Orientation of leaves. Gola cultivar had alternate - opposite leaves orientation, while Bombay, Calcutti and Bedana cultivars had alternate leaves orientation (Table II). The difference is probably due to genetic make up of the cultivars. According to Nakasone and Paull (1998), litchi leaves are arranged alternately, pinnately compound with 2 – 5 pairs of leaflets arranged in opposite positions or slightly obliquely along the rachis. Bal (1997) reported that the litchi plants have alternate, pinnate and leathery leaves with 5 – 7 opposite or alternate leaflets.

Newly emerged flush colour. Gola and Bombay cultivars had reddish brown flush colour while Calcutti cultivar had brownish red and Bedana cultivar had dark pink flush colour (Table II). In litchi, growth of flushes occurs several times a year. Young emerging flushes range from pale green to pinkish to a copperish red in colour (Nakasone & Paull, 1998). According to Singh *et al*. (1999) the litchi cultivars can be distinguished on the basis of colour of flush and season of flushing. They further reported that Shahi cultivar produced very light coloured flush, while cv. China had pink flush. The colour of cv. Bedana flush was very dark pink.

Number of leaflets/leaf. Gola cultivar had 6 – 8, Calcutti cultivar had 5 – 8, Bombay cultivar had mostly 6 and Bedana cultivar had 4 – 6 leaflets per leaf (Table II). The differences might be due to difference in their genetic make up. According to Nakasone and Paull (1998), litchi leaves have 4 – 10 (two to five pairs) leaflets, depending upon the cultivars.

Number of leaves/flush. Gola and Bombay cultivars had 4 – 5 leaves/flush, while Calcutti and Bedana cultivars had 3 – 4 leaves/flush (Table II). Varietal characters were probably responsible for the variations.

Flower Characteristics

Table I. Tree characteristics of the litchi cultivars

Cultivars	Tree height (m)	Canopy width (m)	Tree shape and foliage	Foliage colour
Bedana	7.52 a*	9.85 a	Round, dense, symmetrical canopy	Light green to green
Bombay	6.40 a	6.40 b	Round, dense, symmetrical canopy	Dark green
Calcutti	6.91 a	6. 86 b	Round, less dense, non-symmetrical	Light green
Gola	6.91 a	6.71 b	Round, less dense, mod-erately symmetrical	Light green to green

*Means sharing similar letters in a column are statistically non-significant at 5% probability level (LSD test).

Table II. Leaf characteristics of the litchi cultivars

Cultivars	Leaf length (cm)	Leaf width (cm)	Internodal distance (cm)	Leaf shape and surface conditions	Orientation of leaves	Newly emerged flush colour	No. of leaflets per leaf	No. of leaves per flush
Bedana	11.80 b*	3.00 c	2.00 a	Oval, wavy curved upward, not shiny	Alternate	Dark pink	4 – 6	3 – 4
Bombay	15.80 a	5.10 a	2.20 a	Oval, wavy curved upward, shiny	Alternate	Reddish brown	Mostly 6 but rarely 6 – 8	4 – 5
Calcutti	14.90 ab	3.90 b	2.50 a	Oval, wavy curved downward, very shiny	Alternate	Brownish red	5 – 8	3 – 4
Gola	12.20 b	3.60 bc	2.60 a	Oval, slightly wavy, moderately shiny	Alternate – opposite	Reddish brown	6 – 8	4 – 5

*Mean sharing similar letters in a column are statistically non-significant at 5% probability level (LSD test).

Table III. Panicle, flower and fruit characteristics of the litchi cultivars

Cultivars	Panicle length (cm)		Flower colour	Number of anthers and filament size			Carpels and style size		Fruit colour	Fruit size
	Terminal	Lateral		Staminate	Hermaphro.	Pistillate	Pistillate	Hermaphro.		
Bedana	25.8	15.4	Yellowish	-	6-7, medium	6-7, very short	2, short	2, long	Golden red	Medium
Bombay	26.0	14.0	Yellowish	6-8, long	-	6-8, very short	2, short	-	Red	Medium
Calcutti	26.0	11.6	Yellowish	-	6-8, medium to long	6-8, very short	2, short	2-3, long	Pinkish red	Large
Gola	34.2	23.8	Light yellow	-	6-8, medium	6-8, very short	2, short	2, long	Rose red	Medium

Panicle length. Maximum length of terminal panicle (34.2 cm) was found in Gola cultivar while the minimum (25.8 cm) was recorded in Bedana cultivar. The maximum length of lateral panicle (23.8 cm) was also found in Gola cultivar while the minimum (11.6 cm) was recorded in Calcutti cultivar (Table III). The differences might be due to genetic make up of the cultivars and their response to the environmental conditions.

Flower colour. Gola had light yellow flower colour, while Bombay, Calcutti and Bedana cultivars had yellowish flower colour (Table III). However, Nakasone and Paull (1998) reported that litchi flowers are yellow-green or brownish yellow. The variations might be due to genetic behaviour of the cultivars as floral characters are less affected by the environmental conditions.

Number of anthers and filament size. Staminate flower of Bombay cultivar had 6 - 8 anthers with long filament while Gola, Calcutti and Bedana cultivars had no staminate flower. Hermaphrodite flowers of Gola and Calcutti cultivars had 6 - 8 anthers with medium and medium to long filaments, respectively. Bedana had 6 - 7 anthers with medium sized filaments. This is interesting to record that pistillate flowers of Gola, Bombay and Calcutti cultivars also had 6-8 anthers but with very short filament size, while Bedana cultivar had pistillate flower with 6-7 anthers and very short filaments (Table III). The anthers of pistillate flowers are considered as non-functional. The differences in number of anthers were possibly due to the genetic variation among the cultivars. Bal (1997) reported that litchi plants bear three types of apetalous flowers with up to 8 stamens. The first type flower is morphologically and functionally staminate possessing 6 – 8 stamens and in which the pistil is aborted almost completely. The second type is morphologically a hermaphrodite, functionally mostly as female (pistillate) with well developed two carpel pistil and a two lobed stigma, with 5 – 8 stamens which normally do not dehise. The third type is also morphologically a hermaphrodite but functionally a male with 6 – 8 stamens and a rudimentary pistil lacking style (Nakasone & Paull, 1998).

Number of carpels and style size. Pistillate flowers of all the four cultivars had 2 carpels with short styles. The hermaphrodite flowers of Gola and Bedana cultivars also had 2 carpels while those of Calcutti cultivar had 2-3 carpels but with long styles. Bombay cultivar had no hermaphrodite flowers (Table III). The variation is probably due to the differences in genetic make up of these cultivars. Nacif *et al*. (2001) studied fruit morphology and pericarp anatomy

during the development of the cv. Brewster of litchi. The flowers were functionally male and female, with a superior bicarpellary ovary with two ovules, rarely three. Frequently, only a single fruit developed.

Fruit Characteristics

Fruit colour. Gola cultivar had rose red fruit colour, Bombay cultivar had red fruit colour, Calcutti cultivar has pinkish red fruit colour and Bedana cultivar had golden red fruit colour (Table III). In litchi the colour of fruit varies depending upon the cultivars and is also influenced by growing conditions. Kumar *et al*. (1998) have also recorded variation in phenotypic characters of the litchi fruits (colour, shape and number of tubercles). Differences in fruit colour of litchi cultivars have also been reported by other researchers (Froneman, 1999; Wong, 1999; Yuan & Zhu, 2001). The colour of the fruits was reddish with bottom yellowish in Purbi while it was light reddish in Deshi, Early Bedana, Late Bedana and Kasba (Singh *et al*., 1999). The fruits of cultivar Calcuttia had attractive pinkish red (Mahajan, 2002), Bedana, Naffarpal, Deshi, Early Large Red, Early Muzaffarpur, Mclean, Muzaffarpur and Rose Scented had red or brown (Dwivedi & Jha, 2000), Brewster had red (Nacif *et al*., 2001) and Qinzhou Red had bright red colour (Peng *et al*., 2001).

Fruit size. In litchi, fruit size is a genetic characteristic of the cultivars and is also used for identification of cultivars (Singh *et al*., 1999), although affected by the cultural practices including use of fertilizers. In the present study, it was observed that the Calcutti cultivar had large sized fruits, while rest of the three cultivars had medium sized fruits (Table III). Menzel and Simpson (1990) reported that a large number of cultivars were grown around the world. The shape of skin segments and protuberances were the reliable and stable genetic characteristics, while fruit size, shape and taste were some other variables. Mahajan and Dhillon (2000) evaluated various litchi cultivars and found that the fruits of Calcuttia cultivar (syn. Calcutti) were larger in size having maximum fruit length and diameter. Li *et al*. (2002) found that the difference in fruit size between large (Edanli) and small-fruited (Huaizhi) litchi cultivars was related to both size and activity of the sink.

REFERENCES

Bal, J.S., 1997. *Fruit Growing,* pp: 262–74. Kalyani Publishers, Ludhiana, India

Dwivedi, A.K. and K.K. Jha, 2000. Morphological characters of fruits in litchi *(Litchi chinensis* Sonn.). *J. Res., Birsa Agric. Univ.,* 12: 119–20

Froneman, S., 1999. Two new litchi cultivars released: new litchi cultivars will lengthen the South African production season, *Neltropika Bull.,* 305: 3–6

Galan, S.V., 1989. *Litchi Cultivation (in Spanish) (Menini, U.G., FAO Coordinator)*. FAO Plant Production and Protection Paper No. 83, FAO, Rome, Italy

Groff, G.W., 1921. *The Lychee and Lungan*. Orange Judd, New York

Kumar, M., K. Singh, D.K. Das and R.N. Roy, 1998. Fruit drop, fruit retention and fruit cracking in some promising litchi (*Litchi chinensis* Sonn.) trees. *J. Res., Birsa Agric. Univ.,* 10: 203–6

Li, J.G., X.M. Huang, H.B. Huang and B.Y. Zhou, 2002. A cytological and physiological study of large and small sized litchi cultivars fruit. *J. Fruit Sci.,* 19: 158–62

Mahajan, B.V.C., 2002. Developmental pattern and maturity standards of litchi *(Litchi chinensis* Sonn.) cv. Culcuttia. *Orissa J. Hort.,* 30: 43–5

Mahajan, B.V.C. and B.S. Dhillon, 2000. Evaluation of different cultivars of litchi (*Litchi chinensis* Sonn.) under sub–mountainous regions of Punjab. *Haryana J. Hort. Sci.,* 29: 184–9

Menzel, C.M., 1984. The pattern and control of reproductive development in lychee: A Review. *Sci. Hort.,* 22: 333–45

Menzel, C.M., 1991. *Litchi chinensis* Sonn. *In:* Varheij E.W.M. and R.E. Coronel (eds.). *Plant Resources of South–East Asia,* pp: 191–5. Pudoc, Wageningen

Menzel, C.M. and D.R. Simpson, 1990. Performance and improvement of lychee cultivars: a review. *Fruit Var. J.,* 44: 197–215

Miao, P.S., J. Han, Y.Q. Huang, D. Lin and F.N. Wang, 1998. Introduction of four new litchi selections. *China Fruits,* 2: 53

Nacif, S.R., A.A.S. Paoli and L.C.C. Salomao, 2001. Morphological and anatomical development of the litchi fruit (*Litchi chinensis* Sonn. cv. Brewster). *Fruits,* 54: 225–33

Nakasone, H.Y. and R.E. Paull, 1998. *Tropical Fruits,* pp: 173–207. CAB International, Wallingford, Oxon, UK

Nakata, S. and Y. Watnabe, 1966. Effects of photoperiod and night temperature on the flowering of *Litchi chinensis. Bot. Gaz.,* 127: 146–52

Peng, H.X., Y.C. Li, D.J. Huang, W.Q. Su and R.G. Liu, 2001. Qinzhou Red Litchi a new big fruit form variety of litchi. *Acta Hort.,* 558: 276–8

Rai, M., M.N. Reddy and V.S.R.K. Prasad, 2001. Variation pattern in litchi under Indian conditions. *Indian J. Hort.,* 58: 218–23

Singh, K., B.M. Chowdhary, R. Shankar and B.P. Jain, 1999. Studies on the physiological changes in litchi fruits during growth and development under Ranchi condition. *Prog. Hort.,* 31: 151–5

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics, A Biometrical Approach* pp: 232–51. 2nd Ed. McGraw Hill Book Co. Inc., New York

Wong, D.X., 1999. Introduction of several promising litchi varieties. *China Fruits,* 4: 55

Yuan, P. and L. Zhu, 2001. Preliminary report on trails of four high quality late litchi varieties. *South China Fruits,* 30: 22

(Received 10 August 2004; Accepted 20 September 2004)