Electronic Journal of Plant Breeding, 4(1): 1101-1107 (Mar 2013)
ISSN 0975-928X

Research Note

Genetic variability and diversity study on Bhot jolokia (*Capsicum chinense* Jacq)

[1]R. Hazarika, [1]B. Neog [2]R.N.S. Yadav and [3]S.B. Tripathi
[1]Department of Life Sciences, Dibrugarh University, Assam-786004, India
[2]Centre for Studies in Biotechnology, Dibrugarh University, Assam-786004, India
[3]The Energy and Resources Institute (TERI), IHC Complex, Lodhi Road, New Delhi-110 003, India
Email: ridiphaz@gmail.com

(Received: 16 Feb 2013; Accepted: 23 Feb 2013)

Abstract
Thirty Bhot jolokia (*Capsicum chinense* Jacq) accessions from three different states of north east region were evaluated in a thorough field exploration with enough geographical representation to assess genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h2%) and genetic advance (GA). Higher GCV and PCV were observed for plant height, fruits per plant, fruit weight, fruit length, fruit width and number of seeds per fruit. High heritability coupled with high genetic advance observed for these characters imply the potential for crop improvement through selection. Using the SPSS (version 13.0) software, cluster analysis was performed based on maximum and minimum Euclidian dissimilarity distances which separate the thirty accessions of *C. chinense* into six distinct clusters with distinct morphological variation between the clusters.

Key words:
Capsicum chinense, genetic advance, heritability, variability

The genus *Capsicum*, belongs to the family Solanaceae having significant economic importance is grown worldwide and ranked 7th in the world vegetable production. Most of the pungent chillies are in the range of 100,000 to 500,000 SHU and the world's hottest chilli *Capsicum chinense* Jacq., which originated from north east India, possess 1, 041, 427 units, which is almost twice as hot as the Red Savina pepper and it has been acknowledged as the hottest chilli in the world (Guinness World Records, 2006). It is known by various names in different regions such as 'Bhut/Bhot jolokia' or 'Bih jolokia' in Assam, 'Naga king chilli' in Nagaland, 'Omorok' in Manipur and 'Ghost pepper' by the western media. It is also known by some other names like 'Saga jolokia', 'Indian mystery chilli' and 'Indian rough chilli'. The agro-climatic conditions of north east India is favorable for the cultivation of this type of chilli. The Naga chilli is mainly cultivated in Kohima, Peren, Mon and Dimapur areas in Nagaland as well as in Assam (especially Upper Assam region) and Arunachal Pradesh. Conventionally, the Naga chilli is cultivated in Jhum (shifting cultivation) paddy fields as a sporadic intercrop with summer paddy and also in small homestead gardens. In hilly areas, planting of Naga chilli is done in February to March and the harvesting starts from May to June onwards, while in plains, it is planted in August to September and harvested in November to December. However, in kitchen gardens, the plants stay for 2 to 3 years and grow with a height of about 3 to 4 m (Bhagowati and Changkija, 2009). *Capsicum chinense* has been used conventionally by different ethnic communities of the northeastern India in treating various human ailments. In Nagaland, Naga chilli is used to tone up body muscles after heavy workouts whereas hot infusions are used for toothache and muscle pain (Bhagowati and Changkija, 2009) and the dried fruits are used by the 'Garo' ethnic community of Bangladesh in preparation of fermenting medium for their traditional liquor (Anisuzzaman and Rahman, 2007). Capsaicinoids, the pungency principle of *Capsicum* is used in different pharmaceutical applications due to their analgesic, anti-arthritic, anticancer and antioxidant properties (Szolcsanyi, 2003; Prasad *et al.*, 2005; Mori *et al*., 2006). Investigation also revealed that chilli has higher anti-oxidative capacity than ginger, garlic, mint and onion (Shobana and Naidu, 2000) and so it may play an important role in the process of chemoprevention (Yu *et al.*, 2002).

Morphological characterization, evaluation of the genetic diversity documentation deposition in gene bank are essential to maintain genetic variability in breeding programs (Viana *et al.* 2006, Arriel *et al*. 2007, Lannes *et al.* 2007). Keeping this in mind the present study is aimed to estimate the genetic variability, heritability genetic advance and morphological similarity studies of different *Capsicum chinense* accessions from the different region of the north east India with enough geographical representation.

Thirty accessions of hot chilli (*Capsicum chinense*) were collected from wild, home gardens and local markets of three different states of north east region, *i.e.* Assam, Arunachal Pradesh and Manipur with enough geographical representation thorough an extensive survey between 2010 and 2012. The seeds of Bhot jolokia accession lines were sown in earthen pots and when the seedlings

attained 10 to 15 cm height or at 60 days after sowing, transplanted to individual plots in the departmental gene banks of Dibrugarh University in randomized block design at a spacing of 100 cm between rows and 50 cm between plants with five replications for each accession line with thorough monitoring of morphological and growth characteristics. The accession numbers with place of collection of hot chilli are given in Table 1.

Capsicum species were identified based on the morphological descriptors or related traits, established by the International Plant Genetic Resources Institute (IPGRI) for the genus *Capsicum* (IPGRI 1995), with slight modifications. Five representative plants per accession were selected randomly, tagged and observations were recorded on these plants for different characters. Genotypic and phenotypic coefficients of variations were estimated following the formulae used by Burton (1953). Heritability was estimated as per standard procedures of Hanson *et al*. (1956) and genetic advance as per Robinson *et al.* (1949). SPSS version 13.0 was used for cluster analysis on the basis of morphological parameters.

A wide range of variation was observed among the accessions of *Capsicum chinense* based on thirty-six morphological characters. The frequency percentage for each character was worked out as per Mohammed (1994) and presented in Table 2. In most of the accessions growth habitat was erect having branch angle acute to wide and leaf colour light green with lanceolate leaf shape. Flowers per axil varies between one, two, three or more. Light yellow corolla color, rotate corolla shape was dominant in most of the accessions. Fruit color at immature stage was varied green; light green to orange and at mature stage maximum fruits red in color. Fruit shape elongate to triangular having wrinkled to semi wrinkled fruit surface. Carvalho *et al.* (2003) and Lannes *et al.* (2007) found great genetic variability in the diversity of fruit colors and shapes in *C. chinense*. Significant differences were found among the genotypes for the characters studied. The estimates of range, mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2%), genetic advance (GA) for thirteen characters are presented in Table 3. High PCV and GCV were observed for several characters like yield per harvest, number of seeds per fruit, fruit length, fruit width, fruit weight and plant height. High values of GCV have been reported for both fruit size (Sarma and Roy, 1995) and fruit length (Nandi, 1992).

The Dendrogram based on Ward's method and Euclidian dissimilarity distances categorized the 30 *Capsicum chinense* accessions into six distinct clusters (Fig1). The number of genotypes in each cluster is shown in Table_4. The distribution of genotypes into the various clusters indicates remarkable genetic diversity among all the genotypes for the traits under consideration. The mean values per cluster for selected characteristics are shown in Table_5. Cluster I consisted of eight genotypes, Cluster II of three, Cluster III of eight, Cluster IV of five, Cluster V and Cluster VI consisted of three genotypes. Number of fruits per plant (51.8), number of harvests (4.6 times) and number of primary branches (2.5) were greatest in Cluster I. Number of seeds per fruit (28.8), plant spread (80.4 cm) and number of primary branches (2.5) were greater in Cluster IV. Plant height (85.50 cm), leaf length (10.92 cm), leaf width (5.4 cm), fruit length (4.9 cm), fruit width (2.1 cm), fruit weight (4.63 gm) greatest and minimum numbers of days required to 50% flowering (90.30 days) were in Cluster VI. Cluster I and Cluster VI will be best choice as parents in future hybridization programmes to develop high yield because the genotypes of these clusters had greater number of harvests, fruits per plant, fruit size, weight and less number of days required to flowering and so early fruiting may be possible.

High heritability were observed for most of the characters like plant height, number of primary branches, plant spread, days to 50% flowering, leaf length, leaf width, corolla length, fruit length, fruit width, fruit weight, number of fruits per plant and number of seeds per fruit. Gopalakrishnan *et al.* (1984), Jabeen *et al.* (1998) and Munshi and Behra (2000) also observed high values of heritability for fruit weight, fruit size and yield per plant. GCV together with high heritability and GA are more reliable in predicting the effect of selection than heritability alone (Johnson *et al.* 1955, Bharathiveeramani *et al.* 2012). The per cent of high heritability (h^2%) coupled with high genetic advance was observed for plant height, leaf length, leaf width, fruit length, fruit width, fruit weight, number of fruits per plant and number of seeds per fruit in the present study, which indicate that the selection can be effective for these traits.

Acknowledgement: The authors are thankful to the Department of Biotechnology (DBT), Govt. of India, for the financial support to carry out the research work.

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Table 1. Accession number for 30 accession of *Capsicum chinense* with place of collection

Accession Number	Place of collection	State
AC-001	Biswanath Chariali	Assam
AC-002	Nahorkotia	Assam
AC-003	Bishnupur	Manipur
AC-005	Imphal	Manipur
AC-006	Biswanath Chariali	Assam
AC-007	Baihata Chariali	Assam
AC-009	Dhemaji	Assam
AC-010	Dibrugarh University Botanical Garden	Assam
AC-011	Jokai (Dibrugarh)	Assam
AC-012	Namsai	Arunachal Pradesh
AC-013	Sonapur	Assam
AC-014	Dibrugarh	Assam
AC-015	Hajo	Assam
AC-016	Jorhat	Assam
AC-018	Jorhat	Assam
AC-021	Ledo	Assam
AC-022	Ledo	Assam
AC-028	Jagun	Assam
AC-031	Borgolai	Assam
AC-032	Borgolai	Assam
AC-033	Jagun	Assam
AC-034	Tirap-Gate-I	Assam
AC-035	Tirap-Gate-II	Assam
AC-039	Borgolai	Assam
AC-040	Khowang	Assam
AC-042	Dighola Gaon, Dibrugarh	Assam
AC-044	Borgolai	Assam
AC-045	Tirap District	Arunachal Pradesh
AC-046	Tirap District	Arunachal Pradesh
AC-047	Lohit District	Arunachal Pradesh

Table 2. Frequency percentage for various traits as per the descriptor in *Capsicum chinense*

Traits	Percentage distribution			
Plant growth habit	Erect (56.5%)	Intermediate/ Compact (17.39%)	Prostrate (26.08%)	
Leaf color	Dark green (36.36%)	Light green (63.36%)		
Stem color	Green (31.81%)	Green with purple stripes (68.18%)		
Branch Angle	Acute 60º-30º (60%)	Wide>60º (28%)	Upright (12%)	
Leaf shape	Deltoid (3.84%)	Ovate (23.07%)	Lanceolate (69.23%)	Long-deltoid (3.84%)
Number of flowers per axil	One (4%)	Two (40%)	Three/more (56%)	
Flower position	Erect (36%)	Intermediate (48%)	Pendant (16%)	
Anther color	Blue (60%)	Light purple (12%)	Purple (16%)	Yellow (12%)
Corolla color	Light yellow (88%)	White (12%)		
Corolla shape	Rotate (86.36%)	Campanulate (13.63%)		
Calyx Pigmentation	Absent (12.5%)	Present (87.5%)		
Calyx margin	Entire (20%)	Intermediate (36%)	Dentate (44%)	
Calyx annular constriction	Absent (16%)	Present (84%)		
Fruit color at immature stage	Green (65.38%)	Light green (19.23%)	Orange (15.38%)	
Fruit color at mature stage	Red (77.27%)	Dark Red (9.09%)	Orange (13.63%)	
Fruit shape	Elongate (44%)	Triangular (52%)	Almost round (4%)	
Fruit shape at pedicel attachment	Acute (28%)	Truncate (48%)	Obtuse (20%)	Cordate (4%)
Neck at base of fruit	Absent (68%)	Present (32%)		
Fruit shape at blossom end	Pointed (76%)	Blunt (20%)	Sunken (4%)	
Fruit set	Low (28%)	Intermediate (32%)	High (40%)	
Fruit position	Erect (4%)	Intermediate (20%)	Pendant (76%)	
Fruit surface	Smooth (12%)	Semi wrinkled (36%)	Wrinkled (52%)	
Presence of Anthocyanin	Only node (27.27%)	Whole stem (45.45%)	Leaf vein (13.63%)	Absent (13.63%)

Table 3. Variability parameters for morphological characters in *Capsicum chinense*

Character	Mean ± SD	Range		GCV (%)	PCV (%)	Heritability (%)	GA (%)
		Max	Min				
Plant height (cm)	64.30±21.2	100.5	35	35.03	36.66	91.25	58.02
Number of primary branches	2.21±0.14	4	2	9.27	10.09	83.68	17.48
Plant spread (cm)	70.02±14.48	105	32	20.18	22.08	83.53	37.99
Days to 50% flowering	96.92±10.55	125	63	11.61	12.79	82.44	21.74
Leaf length (cm)	9.51±1.4	13.3	4.0	19.11	19.23	98.71	39.08
Leaf Width (cm)	4.46±0.75	6.9	1.9	19.93	20.05	98.75	40.59
Fruit length (cm)	4.3±0.91	5.7	3.0	30.24	30.40	99.0	62.01
Fruit width (cm)	1.8±0.39	2.5	1.4	26.88	27.55	95.19	53.95
Fruit Weight (gm)/fruit	3.8±1.05	5.3	2.5	31.20	31.41	98.71	63.84
Corolla length	0.70±0.11	1.0	0.4	26.24	27.43	91.53	51.59
Number of fruits per plant	27.86±6.2	35	8.5	31.40	32.41	93.90	62.70
Number of seeds per fruit	23.43±6.0	40.25	8.75	40.68	42.34	92.35	80.55
Number of harvests	3.95±0.65	06	02	13.61	28.88	22.0	13.21

Table 4. Distribution of accessions into different clusters

Clusters	Accessions
Cluster I	AC-001, AC-002, AC-011, AC-014, AC-016, AC-028, AC-032, AC-040
Cluster II	AC-003, AC-007, AC-009
Cluster III	AC-005, AC-010, AC-013, AC-031, AC-033, AC-034, AC-035, AC-039
Cluster IV	AC-006, AC-012, AC-015, AC-044, AC-047
Cluster V	AC-018, AC-021, AC-045
Cluster VI	AC-022, AC-042, AC-046

Table 5. Mean and standard deviation of six clusters for thirteen characters

Morphological Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Plant height (cm)	63±18.5	37±28	67±16.6	73.1±19.5	59.3±18.1	85.5±25.5
Number of primary branches	2.5±0.28	2±0.0	2±0.0	2.5±0.46	2±0.0	2±0.0
Plant spread (cm)	71.53±13.61	59.58±25.71	61.72±9.05	80.4±9.56	74±14.83	77.3±14.70
Days to 50% flowering	100.06±10.07	91.16±1.94	96.63±9.91	95.35±7.74	108.17±10.83	90.3±22.77
Leaf length (cm)	8.86±1.08	5.91±1.70	10.73±0.92	9.76±1.44	9.8±0.50	10.92±1.98
Leaf Width (cm)	4.3±0.60	2.8±0.75	4.73±0.55	4.68±0.45	4.67±0.67	5.4±1.34
Fruit length (cm)	3.83±1.10	4.47±1.72	3.93±0.55	4.22±0.87	4.33±0.57	4.9±0.62
Fruit width (cm)	1.98±0.22	1.33±0.64	1.73±0.24	1.54±0.11	1.66±0.57	2.1±0.53
Fruit Weight (gm)/fruit	3.49±0.92	4.06±1.79	3.23±0.56	3.7±1.3	3.83±1.01	4.63±0.72
Corolla length	0.61±0.11	0.7±0.1	0.71±0.08	0.7±0.18	0.73±0.11	0.7±0.1
Number of fruits per plant	30.31±7.15	27.8±5.2	26±6.3	28.1±4.8	26.6±5.7	27.3±6.8
Number of seeds per fruit	23.25±10.8	22.33±4.5	22.25±8.56	28.8±4.55	18.66±2.08	25±5.19
Number of harvests	4.6±0.64	2.8±0.52	3.9±0.68	3.8±0.47	4.4±0.43	4.0±0.95

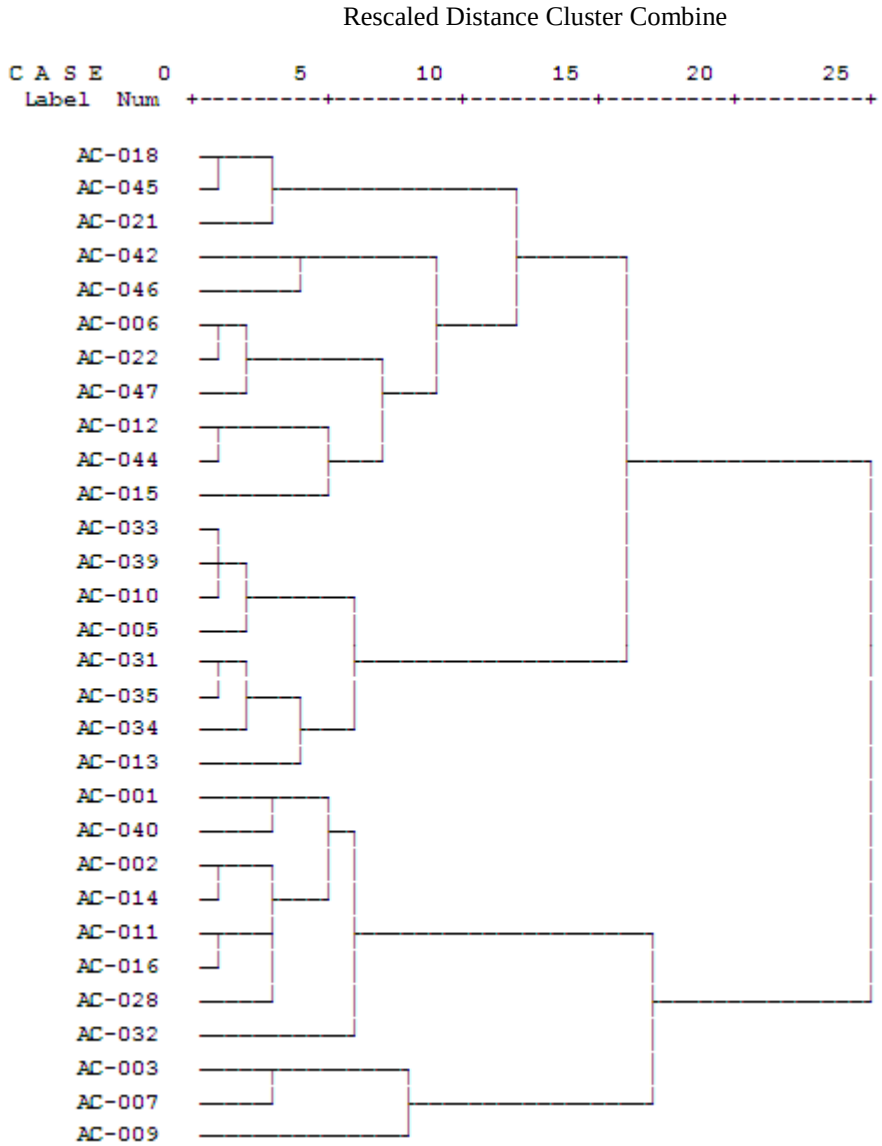

Fig1. Dendrogram using Ward method in SPSS based on morphological traits