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Short Communication

Morphological and biochemical characterization of Long pepper (*Piper longum* L.) genotypes from Western Ghats regions of Kerala, India

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Abstract

Forty one long pepper genotypes along with 'Viswam' were evaluated for qualitative, quantitative and biochemical characteristics including growth, flowering and yield. Observations were recorded during maximum vegetative phase of the crop. Highest inflorescence (more than 55 per cent) was produced during June, July and August and lowest (less than 5 per cent) during December and January, recorded from April 2013 – March 2014. Among the forty two accessions, thirty eight were found to be female, three male and one non-flowering type. Wide variability was observed among accessions for qualitative and quantitative characteristics. In the dendrogram derived based on quantitative data, the accessions showed only 14 per cent similarity.

Key words: Dendrogram, *Piper longum*, Viswam.

Long pepper or "thippali" *(Piper longum* L.), belonging to the family piperaceae, is one of the most extensively used medicinal plants in the Ayurvedic System of Medicine, particularly for diseases of respiratory tract. It is used in over 320 classical compound medicinal formulations and in many modern herbal formulations (Singh et al., 2004). Since it is one among the 14 medicinal plants which has high demand in indigenous drug industry, it is prioritised for cultivation and development by National Medicinal Plant Board. The only improved variety in *Piper longum* released through clonal selection by Kerala Agricultural University was Viswam. The yield potential of Viswam was reported as 472 kg ha^{-1}.

Germplasm collection of long pepper was initiated at the Department of Plantation Crops and Spices in College of Horticulture, Kerala Agricultural University and was further strengthened by KSCSTE funded project, and 60 accessions were assembled. After an initial evaluation, 42 accessions were selected, including check variety Viswam, for the present study. The accessions were collected from Western Ghat regions of Kerala and also from NBPGR which includes the collections from different regions of Karnataka and Tirunelveli. In this background, the present study was planned to catalogue the germplasm accessions of long pepper on the basis of flowering behavior, and fruit set, and to identify superior long pepper genotypes with high yield and quality. Biochemical attributes like volatile oil, oleoresin content and piperine content were also analysed**.** Cluster analysis on qualitative data of 42 accessions and quantitative data of 20 accessions was subjected to Multivariate Hierrarchial Cluster Analysis using NTSYS.

Forty one accessions of long pepper (*Piper longum* L.) and the released variety Viswam, were evaluated

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at the Department of Plantation Crops and Spices, College of Horticulture, Vellanikkara during December 2012 to May 2014 (Table 1). The experimental field is located at an altitude of 22.5m above MSL, between 10º 32[1] latitude and 76º 16 m longitude. The experimental site has sandy loam soil which is acidic in reaction (pH 5.3). The area lies in tropical monsoon climatic region, with more than 80 per cent of the rain fall getting distributed through south west and north east monsoon showers. Experiment was laid out in Completely Randomized Design (CRD), with 42 treatments and six replications. Observations were taken from April 2013 – May 2014, since the flowering started from April 2013. The quantitative characters included plant height, number of primary branches/plant, number of spike bearing branches per primary branch, petiole length, internodal length of spike bearing branch, leaf number, leaf area, days from planting to emergence and emergence to maturity of spike, spike length and girth, spike yield per plant, spike set and driage. The volatile oil, oleoresin and piperine content of twenty samples were recorded as biochemical characters. The quantitative characters of female, male and non-flowering accessions are given in separate tables. Extraction of oil was done by using Clevenger apparatus (AOAC, 1980) for twenty accessions, and oleoresin content in the spikes of *Piper longum* was estimated using Soxhlet apparatus [AOAC, 1980] with acetone for thirty accessions and expressed in per cent. Piperine content in the dried spikes of thirty three accessions was estimated spectroscopically following the method of Sowbhagya et al. (1990). The biochemical characters of only twenty accessions are discussed here, since all the three characters viz., oil, oleoresin and piperine were recorded only in those accessions. Statistical analysis of data was done using MSTATC package. Data based on qualitative and quantitative characters were compared with Euclidean co-efficient and was clustered by the Unweighed Pair Group Method with Arithmetic mean (UPGMA) devised by Sneath and Sokal (1973) using NTSYS pc 2.02 software. Similarity matrix was computed and the dendrogram was constructed accordingly.

Forty one accessions collected from different locations along with check variety 'Viswam' were catalogued based on IPGRI descriptor for *Piper*

Table 1. Details of long pepper accessions included in the study

Sl. No.	Accession No.	Source of collection	Sl. No.	Accession No.	Source of collection
1	PL 1	Viswam	22	PL 26	Vellanikkara
2	PL 2	IC 85299 – Malappuram	23	PL 30	Vellanikkara
3	PL 3	IC85301 – Kasaragod	24	PL 34	Mananthavady
4	PL 4	IC85247 – Kollam	25	PL 35	MSSRF
5	PL 5	IC85278 – Tirunelveli	26	PL 36	Pulpally
6	PL 8	Mananthody big type	27	PL 39	Wayanad
7	PL 9	Mananthody	28	PL 41	Chanthanathode
8	PL10	IC 85277 – Tirunelveli	29	PL 42	Chanthanathode
9	PL 11	IC 85285 – Karnataka	30	PL 43	Chanthanathode
10	PL 12	IC 85298 – Malappuram	31	PL 44	Chanthanathode
11	PL 13	IC 266468 - Tirunelveli	32	PL 47	Kottakkal
12	PL 15	Yercaud	33	PL 49	Kottakkal
13	PL 17	Marotichal big	34	PL 50	Wayanad
14	PL 18	Oushadhi	35	PL 51	Wayanad
15	PL 19	Vydyarathnam	36	PL 52	Wayanad
16	PL 20	Mala	37	PL 53	Wayanad
17	PL 21	Bathery range	38	PL 54	Wayanad
18	PL 22	Thiruvanathapuram	39	PL 56	Pattikkad
19	PL 23	Ambalavayal	40	PL 57	Vazhachal
20	PL 24	Ambalavayal	41	PL 58	Malakkapara
21	PL 25	Ambalavayal	42	PL 69	Thenmala

Table 2. Variability in plant characteristics among female accessions of long pepper

Accessions	Plant height (cm)	No. of primary branches	No. of spike bearing branch/ primary branch	Petiole length (cm)	Internodal length (cm)	Leaf number	Leaf area (cm^2)
Viswam	61.62	7.67	3.85	4.33	5.02	144.83	49.65
PL 2	56.38	6.67	2.87	6.30	5.92	118.66	49.13
PL 3	42.65	5.17	2.17	3.62	5.63	49.33	45.25
PL 4	78.32	4.33	2.97	4.22	5.08	90.16	53.03
PL 5	70.52	4.33	3.67	4.42	5.97	95.50	41.53
PL 8	77.67	5.83	3.25	3.12	6.70	133.67	49.78
PL 9	68.83	3.83	6.72	4.48	6.50	140.50	47.83
PL 10	78.73	4.67	1.75	4.78	7.12	143.17	41.85
PL 11	82.42	4.17	2.58	2.77	3.55	73.67	46.17
PL 12	58.60	4.83	2.45	4.48	6.65	89.17	39.13
PL 13	78.58	5.33	1.20	3.65	7.37	124.50	41.07
PL 15	82.23	5.67	2.95	6.60	6.08	116.67	48.17
PL 17	72.17	3.16	3.53	3.28	6.88	109.00	40.27
PL 18	73.77	4.16	1.58	6.85	6.03	78.50	51.43
PL 19	73.42	4.33	2.00	7.43	6.45	95.67	50.07
PL 20	56.78	5.33	2.63	7.57	5.07	73.50	50.48
PL 21	50.41	6.67	5.70	3.83	4.95	93.33	34.88
PL 22	83.01	4.83	4.48	4.13	5.80	89.50	47.10
PL 23	79.25	8.00	4.57	3.45	4.90	151.33	48.72
PL 24	74.55	8.00	4.88	4.50	4.92	166.00	50.83
PL 25	49.00	7.33	3.85	3.78	6.03	142.00	43.25
PL 34	68.92	8.00	3.12	4.48	6.68	135.17	48.02
PL 35	88.33	3.33	1.67	3.60	6.43	97.83	46.60
PL 36	62.50	6.00	2.47	3.87	5.72	89.00	58.48
PL 41	77.30	4.83	2.82	4.05	6.73	116.67	48.62
PL 42	75.25	6.17	1.42	5.93	6.25	141.33	50.18
PL 43	49.67	7.83	3.58	5.77	5.17	131.33	45.23
PL 44	82.48	6.50	1.33	4.88	6.32	148.83	48.10
PL 49	79.28	4.67	3.13	6.82	6.93	127.17	48.50
PL 50	63.73	6.17	3.22	2.73	5.57	106.00	44.57
PL 51	70.10	3.17	2.35	5.08	5.95	66.33	39.58
PL 52	80.70	4.50	1.50	4.83	5.50	103.00	63.87
PL 53	49.15	1.33	1.00	1.12	1.87	31.83	39.93
Pl 54	39.67	1.00	1.33	2.22	3.02	21.67	25.98
PL 56	79.50	3.67	3.23	5.85	7.02	119.00	38.55
PL 57	61.15	3.00	2.00	3.03	6.92	47.00	42.30
PL 58	69.22	2.33	1.50	4.43	7.38	73.83	35.83
PL 69	79.12	3.83	2.17	5.10	7.08	73.17	34.30
CD (0.05)	7.351	2.254	1.794	0.779	0.595	46.409	3.968
CV (%)	9.40	39.70	56.05	15.27	8.95	39.47	7.71

nigrum showed variation among themselves**.** Accessions included in the study had leaf base shapes such as cordate and round. Leaf margins were wavy and entire. Leaf lamina shape was recorded as cordate, and ovate lanceolate, and veining was of acrodromous types. These types of variations may be due to the genotypic characters of accessions and the findings were supported by Chatterjee and Pakrashi (1997), CSIR report (1998), Ravindran and Balachandran (2005) and Chandran (2012).

In the present study, out of 42 accessions, 38 female accessions, three male and one non - flowering type were observed. Observations based on mean number of inflorescence produced per accession per month from April 2013 – March 2014 indicated that highest production of inflorescences was observed during

June, July and August in all the male and female accessions. 100 per cent flowering in accessions PL 42, PL 53 and PL 57 extended from May to October, but inflorescences did not reach up to maturity in these accessions. This might be the character of the particular accession or might be due to the effect of the geographic location from where it was collected. Kanimozhi (2010) and Kumar (1998) reported that the maximum flowering season in *Piper longum* accessions as May – July and July – August respectively, supporting the results of this study.

During peak vegetative phase, mean number of primary branches ranged from 1.00 to 8.00, plant height ranged from 39.67 cm to 88.33cm, number of spike bearing branches per primary branch from 1.00 to 6.72, leaf area from 25.98 cm^2 to 63.87 cm^2, petiole length from 1.12 cm to 7.57 cm, internodal length of spike bearing branches from 1.87 cm to 7.38 cm and mean number of leaves from 21.67 to 166.0 (Table 2) (in female accessions). In the case of male and non – flowering accessions mean number of primary branches ranged from 4.33 to 6.83, plant height ranged from 60.00 cm to 78.27cm. Number of spike bearing branches per primary branch ranged from 0.00 to 3.08, leaf area from 44.75 cm^2 to 50.32 cm^2, petiole length from 4.12 cm to 6.22 cm, internodal length of spike bearing branches from 5.72 cm to 7.08 cm and mean number of leaves from 78.17 to 143.33. Data on statistical analysis of number of primary branches in male and non – flowering accessions were non – significant (Table 3). Significant differences among accessions might be due to genetic characters or environmental conditions. Variation in characters among different accessions was supported by the comparative evaluation study of five selected types of *Piper longum* by Manuel (1994). Results of the present study are also in agreement with the variability studied by Jaleel (2006) and Chandran (2012).

Number of days from planting to emergence of spike and emergence to maturity varied among accessions. Number of days from planting to emergence ranged from 77 to 146 days, and for emergence to maturity from 60 to 80 days in female accessions. For spike initiation, male accessions took maximum of 141 days and minimum of 135 days and to reach maturity male accessions took maximum of 64 days and minimum of 61 days. This type of variability for emergence and maturity of spike was also reported by Jaleel (2006) [Female: 178 days, male: 132 days for spike initiation; Female: 69.6 days, Male: 56 days for spike maturity] and Suma et al., (2012) (66 – 97 days from emergence to maturity of spikes) (Table 4 & 5).

In female accessions, length of spikes varied from 0.08 cm to 3.10 cm and girth ranged from 3.75 mm to 8.87 mm. In the case of male accessions, spike length varied from 8.10 cm to 8.18 cm, and spike girth varied from 4.00 mm to 4.03 mm. The study revealed that female spikes were shorter than male spikes, but in the case of girth, female spikes were broader than male spikes (Tables 6 & 7). Observations on relative size of female and male spikes are in agreement with Jaleel (2006) [length of female spikes: 2.4 cm – 4.23 cm; male spikes: 7.51 cm – 7.55 cm] and Manuel (1994) [spike length: 4.00 – 4.33 cm]. It was noticed that mean

Table 3. Variability in plant characteristics among male and non - flowering accessions of long pepper

Accessions	Plant height(cm)	No. of primary branches	No. of spike bearing branch/primary branch	Internodal length(cm)	Petiole length(cm)	Leaf number	Leaf area(cm^2)
PL 26	76.67	6.83	1.67	5.15	5.72	140.17	50.32
PL 30	78.27	6.83	1.80	4.12	6.37	78.17	49.38
PL 39	64.65	4.33	3.08	5.08	6.53	94.83	47.98
PL 47	60.00	5.33	0.00	6.22	7.08	143.33	44.75
CD (0.05)	5.066	*NS	1.105	0.812	0.623	49.019	2.385
CV (%)	6.02	44.43	56.00	13.11	8.05	35.66	4.12

*NS : Non Significant

PL 47 was non flowering type

Table 4. Days from planting to emergence and emergence of spike to maturity in female accessions of long pepper

Accessions	Days from planting to emergence	Days from emergence to maturity
Viswam	104.00	61.00
PL 2	113.17	60.00
PL 3	82.00	62.00
PL 4	79.00	66.00
PL 5	116.00	60.00
PL 8	113.00	63.00
PL 9	111.00	69.00
PL10	126.00	80.00
PL11	88.00	66.00
PL12	79.00	64.00
PL13	81.00	62.00
PL15	79.00	64.00
PL17	121.00	64.00
PL18	120.00	64.00
PL19	122.00	64.00
PL20	108.00	69.00
PL21	80.00	65.00
PL22	78.00	67.00
PL23	77.00	66.00
PL24	80.00	63.00
PL25	83.00	74.00
PL34	80.00	66.00
PL35	136.00	0.00
PL36	126.00	61.00
PL41	85.00	68.00
PL42	82.00	0.00
PL43	83.00	63.00
PL44	85.00	63.00
PL49	142.00	76.00
PL50	79.00	76.00
PL51	128.00	77.00
PL52	98.00	74.00
PL53	146.00	0.00
PL54	99.00	0.00
PL56	144.00	74.00
PL57	143.00	0.00
PL58	129.00	65.00
PL69	126.00	79.00
CD (0.05)	43.628	40.674
CV (per cent)	37.08	61.66

number of inflorescences produced had no direct effect on per cent spike set, probably due to the fact that all the inflorescences produced did not reach up to maturity in all accessions.

Among accessions, number of spikes per spike bearing branch ranged from 1.00 to 3.21, fresh

Table 5. Days from planting to emergence and emergence of spike to maturity in male accessions and non – flowering accessions of long pepper

Accessions	Days from planting to emergence	Days from emergence to maturity
PL26	141.00	61.00
PL30	135.00	64.00
PL39	141.00	61.00
PL47	0.00	0.00
CD (0.05)	49.752	41.423
CV (percent)	39.62	73.97

weight per spike ranged from 0.46 g to 1.06 g, dry weight per spike ranged from 0.08 g to 0.20 g, fresh yield per plant ranged from 0.29 g to 58.32 g, dry yield from 0.05g to 9.20 g and driage from 11.62 per cent to 20.66 per cent (Table 6). Among accessions, spike set ranged from 0.00 per cent to 97.42 per cent among female accessions. Observations revealed that higher yield was observed in accession PL 8 and PL 9, and these two accessions also had highest number of spike bearing branches per primary branch, highest number of spikes per spike bearing branch, spike length and girth, fresh and dry yield per plant. Negative correlation of yield with petiole length, leaf area and number of leaves per hill was also shown. Manual (1994) reported that number of spikes per spike bearing branch, number of spike bearing branches per stem and yield of green spike were the most important characters influencing dry spike yield. Correlation of above characters with yield has also been reported by Suma et al. (2012) in *Piper longum* who also found negative association of yield per plant with petiole length and leaf area. Same correlation of yield with *Piper nigrum* was also reported by Nair et al. (1984).

The accessions showed wide variation for qualitative parameters such as volatile oil, oleoresin and piperine contents (Table 8). Among them only twenty accessions were analysed for all the three biochemical characters. Oleoresin content varied from 3.21 per cent to 20.21 per cent, the highest value being with PL 5 and lowest with PL 43. Such kind of variation in oleoresin content of genotypes

Table 6. Variability in yield characteristics among female accessions of long pepper

Accessions	No. of spikes/ spike bearing branch	Spike length (cm)	Spike girth (mm)	Fresh wt/ spike (g)	Dry wt /spike (g)	Fresh yield /plant (g)	Dry yield /plant (g)	Spike set (percent)	Driage (percent)
Viswam	2.25	2.25	6.83	0.69	0.13	42.73	8.36	96.85	19.56
PL 2	1.70	3.10	4.40	0.77	0.15	11.67	2.13	77.77	18.18
PL 3	1.68	1.68	6.300	0.52	0.09	10.11	1.89	71.76	18.71
PL 4	1.92	2.42	5.07	0.84	0.14	24.21	4.12	90.98	16.98
PL 5	2.22	2.17	6.08	1.06	0.19	26.56	4.88	92.64	18.37
PL 8	2.22	2.70	7.38	1.07	0.16	58.33	9.20	97.42	15.77
PL 9	2.08	2.58	5.22	1.00	0.16	50.61	8.59	97.21	16.97
PL 10	1.00	2.38	3.98	0.55	0.11	1.01	0.19	80	18.81
PL 11	1.92	1.60	6.80	0.50	0.09	9.46	1.79	92.70	18.83
PL 12	1.15	2.38	5.17	1.04	0.20	16.79	3.22	90.90	19.11
PL 13	1.03	2.15	4.05	0.48	0.09	0.63	0.11	66.66	15.87
PL 15	2.33	2.87	5.10	0.96	0.18	29.19	5.28	96.05	18.08
PL 17	1.05	1.93	7.33	0.84	0.16	14.33	2.03	94.11	14.17
PL 18	1.25	2.43	6.62	0.49	0.09	1.45	0.24	72.22	16.55
PL 19	1.17	2.65	3.75	0.13	0.16	0.43	0.05	33.33	11.62
PL 20	1.60	2.03	7.38	0.80	0.15	10.42	2.16	82.11	20.63
PL 21	1.65	2.10	6.93	0.50	0.09	19.74	3.96	95.92	20.01
PL 22	1.67	2.00	6.87	0.55	0.10	14.40	2.74	90.51	18.95
PL 23	1.12	2.12	5.43	0.60	0.09	32.69	4.68	96.72	14.29
PL 24	1.67	2.20	6.62	0.52	0.10	27.26	4.82	93.89	17.68
PL 25	1.40	2.02	6.65	0.69	0.11	29.43	4.75	95.14	16.14
PL 34	1.02	2.78	6.12	0.74	0.15	5.29	1.08	77.27	20.45
PL 35	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL 36	1.33	2.63	7.05	0.64	0.13	3.33	0.68	85.71	20.42
PL 41	1.08	2.17	4.52	0.80	0.15	0.29	0.06	25	17.24
PL 42	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL 43	1.23	2.62	3.93	0.59	0.11	6.54	1.27	89.33	19.29
PL 44	1.50	2.17	6.55	0.59	0.12	0.53	0.08	45.45	15.09
PL 49	1.25	2.83	5.67	0.69	0.13	3.06	0.63	78.26	20.66
PL 50	1.23	2.93	6.33	0.62	0.12	13.91	2.68	95.92	19.19
PL 51	3.22	2.77	6.00	0.85	0.17	9.69	1.74	95.65	17.87
PL 52	3.22	1.77	8.87	0.79	0.15	2.65	0.52	72.00	19.31
PL 53	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL 54	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL 56	1.33	0.82	6.00	0.81	0.16	1.46	0.29	55.55	20
PL 57	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PL 58	2.25	2.52	7.88	0.98	0.19	1.80	0.27	66.66	15
PL 69	1.67	1.47	6.40	0.47	0.08	0.33	0.06	41.66	17.57
CD (0.05)	0.973	0.283	0.408	0.112	0.021	16.661	2.885	-	-
CV (per cent)	53.84	12.62	6.87	16.22	15.96	116.48	114.56	-	-

*PL 47 was non-flowering type

Table 7. Variability in yield characteristics among male and non - flowering accessions of long pepper

Accessions	No: of spikes/ spike bearing branch	Spike length (cm)	Spike girth (mm)	Fresh wt/spike (g)	Dry wt/spike (g)	Fresh yield/ plant(g)	Dry yield/ plant (g)	Spike set (percent)	Driage (per cent)
PL 26	1.50	8.10	4.03	-	-	-	-	-	-
PL 30	1.67	8.10	4.00	-	-	-	-	-	-
PL 39	1.67	8.18	4.03	-	-	-	-	-	-
*PL 47	-	-	-	-	-	-	-	-	-
CD (0.05)	0.859	0.163	0.128	-	-	-	-	-	-
CV (per cent)	59.00	2.22	3.52	-	-	-	-	-	-

Table 8. Variability in qualitative parameters among accessions of long pepper

Accessions	Volatile oil content (per cent)	Oleoresin content (per cent)	Piperine content (per cent)
Viswam	1.50	14.21	0.79
PL 2	0.60	18.00	1.08
PL 3	0.50	17.00	0.56
PL 4	0.50	10.70	0.24
PL 5	0.80	20.21	0.61
PL 8	1.60	9.72	0.85
PL 9	1.00	9.00	0.76
PL 11	0.50	11.71	0.97
PL 12	1.60	20.00	0.87
PL 15	1.32	11.20	0.96
PL 17	1.00	11.00	0.47
PL 20	0.50	9.22	1.01
PL 21	0.71	13.70	0.65
PL 22	1.20	15.20	0.68
PL 23	0.80	10.71	0.73
PL 24	0.80	9.50	0.92
PL 25	0.50	19.70	0.78
PL 43	1.22	3.21	0.30
PL 50	1.00	11.51	1.10
PL 51	0.60	20.00	0.73
C D (0.05)	0.773	6.151	*NS
C V (percent)	73.96	40.45	59.61

was also observed by Chandran (2012). Volatile oil content showed variation, ranging from 0.50 per cent to 1.60 per cent. The lowest contents were in PL 3, PL 11 and PL 20 and highest content in PL 8 and PL 12. Piperine, the pungent principle of long pepper, was found to vary from 0.24 per cent to 1.10 per cent. The lowest piperine content was obtained with PL 4 and highest with PL 50 (Table 8). The data on piperine content observed as non – significant. Similar variations for oil and piperine contents were also reported by Manuel (1994), Sawangjaroen et al., (2004), Ravindran and Balachandran (2005) and Jaleel (2006) in *Piper longum* accessions. The variation observed in the piperine content of genotypes could probably be due to the presence of gene modifying factors for pungency (Sreelathakumary, 2000). Varietal variation in pungency was reported by Anu et al. (2002) in paprika and paprika - like chillies, and by Manju and Sreelathakumary (2002) and Kumar et al., (2012), in chillies.

Quantitative data of 20 accessions showed only 14 per cent similarity and the germplasm collections were highly variable with respect to the various quantitative characters. Among them PL 4, PL 11 PL 17 and PL 51 showed 100 per cent similarity (Fig.1). This might be due to the free exchange of propagating materials from one place to another. This was also reported by Rahman et al., (1997). Dendrogram based on quantitative characters of twenty accessions was drawn by multivariate hierrarchial cluster analysis using NTSYS (Fig.1).

Selection of accessions were done based on yield contributing characters like spike length, spike girth, fresh weight per spike, dry weight per spike, fresh yield per plant, dry yield per plant, driage per plant,

Table 9. Cluster mean value of quantitative characters

Cluster	P to E	E to M	L	G	Sp/ br	FW	DW	DS	FY	DY	DP	SS	O	OL	P
I	104	61	2.25	6.83	2.25	0.68	0.12	18.41	42.72	8.36	**19.85**	96.85	**1.50**	14.21	0.79
II	80	67.6	2.37	6.23	1.39	0.60	0.10	17.70	29.79	4.74	15.28	95.25	0.70	13.30	0.81
III	112	66	**3.01**	**8.37**	**3.21**	**1.03**	0.15	15.31	**54.46**	**8.89**	16.46	**97.31**	1.30	9.36	0.80
IV	97.2	64	2.34	6.24	1.52	0.63	0.11	19.13	8.82	1.67	14.33	84.79	0.46	14.32	0.86
V	110.4	**71.80**	2.45	5.82	1.24	0.58	0.10	18.93	3.99	0.76	5.70	74.37	0.20	6.38	0.87
VI	81	63.6	2.19	5.25	1.46	0.58	0.09	17.49	12.24	3.26	15.36	82.93	0.58	8.92	0.43
VII	88.66	65.66	2.42	5.88	1.69	0.93	0.17	19.17	18.80	3.54	12.76	89.68	1.14	13.47	**0.94**
VIII	122	68.50	2.13	6.04	2.14	0.94	**0.48**	18.91	18.12	3.30	15.10	94.14	0.70	**20.10**	0.67
IX	116	67.60	2.19	6.64	1.83	0.87	0.16	**19.50**	6.25	0.93	5.45	77.59	0.30	10.74	0.41
X	**119.25**	71.25	1.79	5.16	1.30	0.71	0.39	19.32	0.62	0.11	2.88	38.88	0	8.30	0.44
XI	113.66	20.66	2.70	1.34	1.23	0	0	0	0	0	0	0	0	0	0

P to E : days from planting to emergence
E to M : days from emergence to maturity
L : length of spike (cm)
G : girth of spike (mm)
Sp/br : no: of spikes/ spike bearing branch
FW : fresh weight/ spike (g)
DW : dry weight/ spike (g)
DS : driage/ spike (%)
FY : fresh yield/ plant (g)
DY : dry yield/ plant (g)
DP : driage/ plant (%)
S S : spike set(%)
O : oil content (%)
OL : oleoresin content (%)
P : piperine content (%)

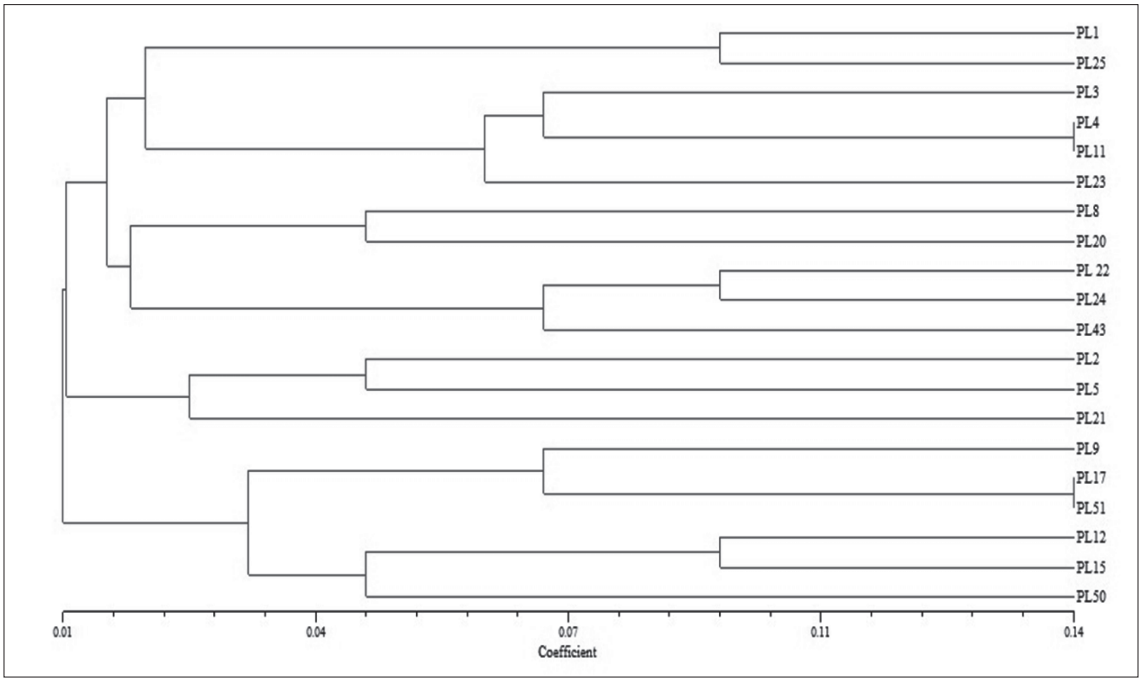

Fig.1 . Dendrogram based on quantititative characters of twenty accessions

spike set and biochemical characters like oil, oleoresin and piperine content. The accessions PL 5, PL 8, PL 9 PL 15, PL 23, PL 24 and PL 25, and considering the biochemical aspects volatile oil, oleoresin and piperine content, accessions PL 8, PL 12, PL 5, PL 50 along with check variety were found to be promising. Since the study was conducted only for one year, it has to be repeated for more years and locations to confirm the results.

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