Journal of Spices and Aromatic Crops 11 (1) : 41-44 (2002)

Genetic variability for clonal selection in Java citronella (*Cymbopogon winterianus* Jowitt.)

R K Lal

Department of Genetics and Plant Breeding
Central Institute of Medicinal and Aromatic Plants
Lucknow-226 015, Uttar Pradesh, India.

Received 21 May 2001; Revised 20 April 2002; Accepted 26 June 2002.

Abstract

Java citronella (*Cymbopogon winterianus* Jowitt.) grass is one of the important aromatic plants of South Asia. Its oil is used extensively as a source of important perfumery chemicals. The nature and amount of genetic variability and stability factor, among 34 diverse accessions of Java citronella assembled from different states of India and Sri Lanka were estimated based on 14 quantitative and qualitative traits. The heritability in broad sense (h^2 BS %) was generally high for all the traits (91.02 - 98.96 %). However, it was medium for leaf length (71.40 %) and plant height (71.61 %) and low for citronellal content (10.65 %) and oil yield (40.57 %). Generally clones were highly unstable for elemol content (SFi = 28.67), followed by herb yield (SFi = 14.67), oil yield (SFi = 10.50), citronellal content (SFi = 8.18), citronellol content (SFi = 7.20), gerenyl acetate (SFi = 3.77), tillers plant^{-1} (SFi = 3.47) and geraniol content (SFi = 3.07). However, leaf width (SFi = 1.68) and leaf length (SFi = 1.85) were found stable to some extent. The plant height (SFi = 2.31) followed by limonene content (SFi = 2.4), oil content (SFi = 2.6) and citronellyl acetate (SFi = 2.96) were moderately stable. Based on the magnitude of stability factors and different genetic parameters, clone Nos. 10, 20 and 3 for high biomass; 28, 30 and 2 for high oil and 1, 9 and 12 for high oil and citronellol content were identified for commercial exploitation.

Key words: clonal selection, *Cymbopogon winterianus*, genetic advance, genetic divergence, heritability, Java citronella, stability factor.

Introduction

Java citronella (*Cymbopogon winterianus* Jowitt.), a perennial leafy aromatic grass, is widely grown in different agro-climatic regions of South Asia including India and Sri Lanka. The oil as such is exclusively used in scenting soaps and other household cleaners, detergents etc. (Husain *et al.* 1994). This oil is also a mosquito repellent, besides being a potential germicide. In addition, it is a source of citronellal, citronellol, geraniol, geranyl acetate, citronellyl acetate, limonene etc., which are used in soap, perfumery, cosmetic and flavouring industries (Husain *et al.* 1994; Sharma *et al.* 1983).

C. winterianus is indigenous to Sri Lanka and originated from *C. nardus* (Ceylon citronella) by spontaneous mutation. The indigenous production of citronella oil falls much short of our internal demand. Non-availability of improved clones with high productivity is one of the major causes for low yield of citronella oil in India. Since the crop is vegetatively propagated and viable seed setting is nearly absent in North India, it is necessary to develop improved clones by utilizing the existing variability through clonal selection.

Materials and methods

Out of various accessions assembled from different places in India and Sri Lanka, 34 accessions were selected for the present investigation. To evaluate variations for plant traits, each selection was planted in a single row, 3 m long and 50 cm apart in a randomized block design with three replications. The soil was prepared using a standard fertility regime of 80 kg nitrogen, 40 kg phosphorous and 40 kg potassium ha^{-1}.

Observations were recorded for 14 economic traits, namely plant height, tillers $plant^{-1}$, leaf width, leaf length, herb yield, oil content, oil yield and citronellal, citronellol, geraniol, citronellyl acetate, geranyl acetate, limonene and elemol in the essential oil. The data were subjected to analysis for simple statistical and genetic parameters, namely, mean ($\overline{X}$), range, variance components (genetic - $\sigma^2 g$, phenotypic- $\hat{\sigma}^2 p$ and environmental- $\sigma^2 e$), coefficient of variation at genotypic (CVg) and phenotypic (CVp) levels, heritability in broad sense ($\hat{h}^2$BS) and genetic advance (GA). The analysis of genetic divergence was done using $D^2 \leq$ statistics (Mahalanobis 1936). The stability factor (SFi) was computed by the formula SFi = Hmi/Lmi (where, Hmi = the highest mean, Lmi = the lowest mean of the th clones) according to the method described by Sharma *et al.* (1983).

Estimation of essential oil was done in fresh biomass (fresh leaves + stems) by hydrodistillation, using Clevenger apparatus. The oil composition was analyzed by GC, using a Perkin Elmer model 3920-B with TCD fitted with 2 m x 3 mm SS column packed with 10% FFAP on 80/100 chromosorb WAW. Column oven was temperature programmed from 80° ≤ 200° C @ 4° m^{-1} with initial and final hold of 2 m and 8 m, respectively, carrier H2 flow 30 ml min^{-1}. The injector and detector temperatures of 200° C and 250° C, respectively, were maintained. Data were processed on HP-3390 integrator. Identification of constituents was

Table 1. Genetic variability parameters for the economic traits in Java citronella

Genetic para-meter	Plant height (cm)	Tillers $plant^{-1}$	Leaf width (cm)	Leaf length (cm)	Herb yield (kg $plot^{-1}$)	Oil content (%)	Oil yield (kg $plot^{-1}$)	Citronellal content (%)	Citronellol content (%)	Geraniol content (%)	C.A (%)	G.A. (%)	Limonene (%)	Elemol (%)
$\hat{\sigma}^2 g$	438.46	529.53	0.08	253.97	1.11	0.04	0.001	104.71	9.48	32.98	1.72	2.80	0.21	30.00
$\hat{\sigma}^2 p$	564.98	532.56	0.09	355.69	1.22	0.04	0.003	483.21	9.51	33.05	1.74	2.86	0.22	30.05
CVg (%)	16.91	28.59	11.22	16.92	67.09	17.14	34.66	31.48	28.81	30.16	30.56	26.87	17.43	75.21
CVp (%)	19.20	28.67	11.39	19.43	70.05	18.06	54.42	96.46	28.86	30.19	30.91	27.01	18.03	75.33
CV (%)	9.08	2.16	1.95	10.39	20.12	5.71	41.95	91.18	1.67	1.43	4.67	2.75	4.63	3.13
$\hat{h}^2$BS (%)	71.61	99.43	97.06	71.40	91.75	90.02	40.57	10.65	99.66	99.78	97.72	98.96	93.40	99.83
GA	33.48	47.13	0.58	23.44	1.99	0.35	0.03	2.24	6.32	11.80	3.37	2.68	0.88	11.26
Mean	120.52	79.89	2.52	97.07	11.58	1.11	0.08	29.56	10.59	19.04	4.58	5.47	2.60	7.26
± SE	6.49	1.00	0.03	5.82	0.18	0.04	0.03	17.11	0.10	0.16	0.15	0.08	0.07	0.13
Range of means	80.40 - 185.70	36.00 - 125.00	1.90 - 3.20	70.00 - 129.70	0.30 - 4.40	0.50 - 1.30	0.02 - 0.21	5.50 - 45.00	2.00 - 14.40	16.30 - 50.10	2.30 - 6.80	2.20 - 8.30	1.50 - 3.60	0.60 - 17.20
CD (1%)	24.43	3.78	0.11	21.90	0.69	0.14	0.10	64.37	0.39	0.59	0.55	0.29	0.26	0.49

CA-Citronellyl acetate; GA-Geranyl acetate; $\hat{\sigma}^2 g$ and $\hat{\sigma}^2 p$ - Genotypic and phenotypic variance; CVg and CVp- Coefficient of variation due to genotype and phenotype; $\hat{h}^2$BS (%)- Heritability in broad sense; GA- Genetic advance.

Table 2. Influence of stability factor (SFi) for the economic traits in Java citronella.

Character	Stability factor (SFi)	Type of influence of SFi	$\overline{D}^2$-values
Plant height	2.31	Medium	125.36
Tillers plant^{-1}	3.47	Low	5963.36
Leaf width	1.68	High	1277.66
Leaf length	1.85	High	135.84
Herb yield	14.67	Low	355.01
Oil content	2.60	Medium	345.53
Oil yield	10.50	Low	124.08
Citronellal content	8.18	Low	16.98
Citronellol content	7.20	Low	10441.48
Geraniol content	3.07	Low	16356.33
Citronellyl acetate content	2.96	Medium	7375.25
Geranyl acetate content	3.77	Low	4725.93
Limonene content	2.40	Medium	847.10
Elemol content	28.67	Low	31260.78

Stability factor (SFi): high < 2; medium (2 - 3) and low > 3

based on retention data of reference compounds.

Results and discussion

Genetic variability among the accessions of Java citronella was relatively large. Analysis of variance for different traits revealed highly significant differences among the accessions for all the traits indicating the existence of considerable genetic variability among the accessions (Table 1). The broad spectrum of variability is also confirmed by D^2 analysis (Mahalanobis 1936). The D^2 ranged from 16.98 to 31260.78 (Table 2).

Medium CVg and CVp were recorded for plant height resulting in the medium heritability (77.61%) coupled with high genetic advance (33.48), suggesting further scope of genetic improvement. High heritability was associated with moderate CVg to low genetic gain resulting from moderate CVg and CVp for number of tillers plant^{-1}, leaf length and citronellol content. Variability in clones of Java citronella at intra-population levels was also recorded for number of traits earlier by Sharma *et al.* (1983). However, the range and variability in the accessions in the present study were much wider for all the quantitative and qualitative traits (Table 1).

The heritable portion of phenotypic variance (s^2p) reflected by the size of genotypic variance (s^2g) was expressed as heritability percent in broad sense (h^2BS) and corresponding genetic advance. The heritabitity (h^2BS) was generally high for all the traits (91.02 - 98.96 %). However, it was medium for leaf length (71.40%) and plant height (71.61%) and low for citronellal content (10.65%) and oil yield (40.57%). The genetic advance was high for number of tillers plant^{-1} (47.13) followed by plant height (33.48), leaf length (23.44) and medium for geraniol (11.80) and elemol (11.26) contents. Other traits expressed low genetic advance (0.03 - 6.32).

The percentages of CVg and CVp for all the traits were examined. The CVg and CVp estimates were comparable and CVg values were slightly less than CVp for all the traits, namely leaf width, herb yield, oil content, citronellal, geraniol, citronellyl acetate, geranyl acetate, limonene and elemol content indicating vulnerability to environmental fluctuations. High heritability was coupled with low genetic advance, attributing to low phenotypic variances (geranyl acetate - 98.9%, 2.68, 2.86; citronellyl

Table 3. Mean performance of superior accessions for important economic traits in Java citronella

Character \ Superior accession*	No.10 (High biomass)	No.20 (High biomass)	No.3 (High biomass)	No.28 (High oil content %)	No.30 (High oil content %)	No.2 (High oil content %)	No.1 (High oil & citronellal %)	No. 9 (High oil & citronellal %)	No.12 (High oil & citronellal %)
Plant height (cm)	185.7	180.0	184.3	119.0	118.0	132.3	130.9	80.4	103.3
Tillers plant^{-1}	70.0	83.3	60.0	65.2	82.1	91.7	125.0	108.9	94.1
Leaf width (cm)	2.6	3.1	2.9	2.2	2.3	2.9	2.7	2.6	1.9
Leaf length (cm)	128.7	129.7	129.3	79.7	104.3	85.1	97.4	85.7	106.8
Herb yield (kg plot^{-1})	4.8	4.4	4.1	1.1	1.5	2.1	2.5	1.8	0.8
Oil content (%)	0.5	0.5	0.5	1.3	1.2	1.1	1.3	1.2	1.1
Oil yield (%)	0.11	0.11	0.11	0.18	0.18	0.17	0.21	0.14	0.09
Citronellal content (%)	9.6	10.3	5.5	30.7	38.2	36.9	42.7	45.0	39.0
Citronellol content (%)	7.7	10.0	2.0	11.5	5.7	7.4	14.4	13.0	7.6
Geraniol content (%)	18.1	18.1	19.3	18.4	18.8	18.2	21.9	20.8	16.4
Citronellyl acetate (%)	4.8	5.9	5.2	2.3	4.2	3.2	6.3	4.8	3.8
Geranyl acetate (%)	5.7	6.3	7.2	5.3	6.1	3.3	8.3	6.9	3.1
Limonene content(%)	2.7	2.4	1.5	2.3	2.9	2.3	2.8	2.2	2.3
Elemol content (%)	8.5	8.3	1.4	15.4	15.0	7.2	1.3	0.6	4.8

* Based on mean of the six cuttings in two years.

acetate - 97.72%, 3.37, 1.74; leaf width - 97.06%, 0.58, 0.09; limonene - 93.40%, 0.88, 0.22; herb yield - 91.75%, 1.99, 1.22; and oil content - 90.02%, 0.35 and 0.04, for the high heritability, genetic advance and low phenotypic variance, respectively) revealed that chances of genetic amelioration for the traits are meager (Table 1).

Generally accessions were highly unstable for elemol content (SFi = 28.67) followed by herb yield (SFi = 14.67), oil yield (SFi = 10.50), citronellal content (SFi = 8.18), citronellol content (SFi = 7.20), geranyl acetate (SFi = 3.77), number of tillers plant^{-1} (SFi = 3.47), and geraniol content (SFi = 3.07), while the accessions were stable for leaf width (SFi = 1.68) and leaf length (SFi = 1.85) (Table 2). It is also evident from the present investigation that different clones differ greatly from each other for nearly all the traits. The study further revealed that the selection based on higher fresh biomass yield followed by oil content will definitely lead to increased oil yield of better quality, as evident from high to medium heritabllity and genetic advance, low to medium stability factors (SFi) and other genetic parameters for the genetic improvement of this crop. Hence, based on above findings, accession Nos. 10, 20 and 30 for high biomass yield; accession Nos. 28, 30 and 2 for high oil yield and accession Nos. 1, 9 and 12 for high oil and citronellal content were found promising (Table 3) for commercial exploitation. Herb yield coupled with oil content or oil yield with better oil composition (high citronellal and low elemol content) are of greater importance than oil yield only. Thus, while selecting for oil yield, quality parameters should also be considered in the crop improvement programmes of Java citronella.

References

Husain A, Sharma J R, Puri H S & Tyagi B R 1994 Genetic resources of important medicinal and aromatic plants in South Asia : A status report pp. 228-238. IBPGR, Rome.

Mahalanobis P C 1936 On the generalized distance in statistics. Proc. Natl. Sci. (India) 2 : 49-55.

Sharma J R, Mishra H O, Lal R K & Uniyal G C 1983 Intrapopulation clonal variation over time and its utilization in genetic improvement of citronella Java (*Cymbopogon winterianus*). Indian Perfumer 27 : 132-136.