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On genetic diversity in germplasm of vetiver '*Veteveria zizanioides* (L.) Nash'

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ABSTRACT

Genetic divergence among 40 genetic stocks of vetiver '*Veteveria zizanioides* (L.) Nash' assembled from different places of India and abroad (Indonesia, Reunion, Haiti and Thailand) were quantified by multivariate analysis for plant height, tillers, fresh, dry root, root length, oil content and oil yield. All the accessions could be grouped into six clusters. Dry root yield, oil content, plant height and oil yield were found to be the common forces of divergence at all the three inter, intra-cluster and inter-genetic levels of differentiation. Diverse agro-ecological conditions, migration of genetic material due to genetic drift, gene flow, out crossing, introduction/exchange of genetic stocks at National and International levels, introgression, mutations, coupled with natural and or artificial selection are the possible factors responsible for such a diversity in vetiver grass. Heritability estimates were over 90 percent for all the characters studied except dry root/plant (78.08%), indicating selection was possible.

1. Introduction

The vetiver (*Vetiveria zizanioides* (L.) Nash ex Small), Family-Poaceae, is native to India and is found growing wild in almost all parts of the country. Roots of vetiver are the source of world-renowned 'khus' oil that has considerable value in essential oil industries. It can be grown on marginal soils, including saline and sodic, sandy, waterlogged and sloppy land. Out of the two species occurring in India, *V. zizanioides* and *Vetiveria lawsoni* only the former has commercial significance because of high class perfumery value of its oil, known since ancient times (Husain et al., 1994; Patra et al., 2005). In India, vetiver grows luxuriantly in Uttar Pradesh, Rajasthan, Southern and peninsular India. The total world production of vetiver oil is estimated to be 300–350 tons per year. The annual consumption and demand is likely to increase further. In India, about 100 tons of oil is produced annually, which is below the indigenous demand levels of the oil for perfume, essence, attar and soap industries (Virmani and Datta, 1975; Lal et al., 2005). Quality of vetiver oil, especially from north Indian origin, is considered to be the best in the world (Lal et al., 1996). The major vetiver oil producing countries are India, Indonesia and Haiti. Vetiver grows wild in some states and its cultivation is also done on limited scale in Andhra Pradesh, Tamilnadu and Kerala. Recently, farmers in north India have taken up vetiver cultivation on large scale due to high demand of vetiver oil.

The genetic variability in this crop is very high. Since the study of genetic variability for diverse morpho-economic traits in the vetiver genetic stocks is a prelude to potential crop improvement, genetic divergence among them was quantified by multivariate analysis with objectives: (i) to assess the proximity of collections/genetic stocks each other thus classify them in different clusters/groups. (ii) To identify highly divergent genetic stocks for further utilization and exploitation in heterosis breeding programme in vetiver crop.

2. Materials and methods

A set of forty, indigenous and exotic collections of vetiver (*V. zizanioides* (L.) Nash ex Small), representative of thirteen states of India (Uttar Pradesh, Uttranchal, Rajasthan, Bihar, Punjab, Madhya Pradesh, Gujarat, Delhi, Jammu and Kashmir, Odisha, Maharastrya, Keral, Andhra Pradesh) and four exotic collections from Indonesia, Haiti, Thailand and Reunion Island constituted the material for the present study (Table 1). They were grown in randomized block design (RBD) repeated thrice at the Research Farm of CSIR-Central Institute of Medicinal and Aromatic Plants P.O. CIMAP, Lucknow U.P. (India) and evaluated for three years (2004–05, 2005–06, 2006–07) under normal fertilization regime (50 kg N + 80 kg P_2O_5 + 80 kg K_2O/ha). The plot size consisted of a pair of 5 m long rows spaced 60 cm. Interplant distance within a row was maintained at 50 cm. Normal cultural practices were followed during crop season. Plants were harvested by uprooting 12 months after planting.

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Table 1
Origin/places of collection of 40 accessions of vetiver maintained at CIMAP, Lucknow.

S. No.	Accessions	Origin/places of collection
1.	RL-1	Razaganj, Lakhimpur (Kheri), U.P. (Uttar Pradesh), North India
2.	TC-4	Travancore, Kerala, South India
3.	SEL-1	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
4.	BRT-5	Bharat Pur, Rajasthan, North India
5.	GHT-1	Ghaghraghat, U.P. (Uttar Pradesh), North India
6.	RI-1	Reunion, Island
7.	OD-1	Odakkali, South India
8.	KS-1	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
9.	KS-2	CIMAP, Lucknow, U.P., North India
10.	IN-1	Indonesia
11.	GULABI[a]	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
12.	BSG-1	Basari Ghat U.P. (Uttar Pradesh), North India
13.	BBG-1	Baba Ganj, U.P. (Uttar Pradesh), North India
14.	MTR-1	Mathura, U.P. (Uttar Pradesh), North India
15.	BDP-2	Pantnagar, Uttrakhand, India
16.	MZP-1	Muzafferpur (Bihar), India
17.	GHS-1	Ghana Sanctuary, Bharat Pur, Rajasthan, India
18.	RJ & K	Jammu Tawi, Jammu and Kashmir, India
19.	PUN-2	Phagwara, Punjab, India
20.	CTK-1	Cuttak, Odisha, India
21.	RRLB-1	Bhubeneswer, Odisha, India
22.	AGR-1	Agra, U.P. (Uttar Pradesh), North India
23.	THAI-1	Thailand
24.	HAITI-1	Haiti
25.	MHA-1	Pune, Maharastra, India
26.	KH-8	Kanpur, U.P. (Uttar Pradesh), North India
27.	CIM VRIDDHI	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
28.	PH-8	New Delhi, India
29.	BBK-1	Barabanki, U.P. (Uttar Pradesh), North India
30.	DHARINI	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
31.	KESARI[b]	CIMAP, Lucknow, U.P. (Uttar Pradesh), North India
32.	AMH-1	Hyderabad Andhra Pradesh, India
33.	JHS-1	Jhansi, U.P. (Uttar Pradesh), North India
34.	MD-1	Moradabad, U.P. (Uttar Pradesh), North India
35.	KKR-1	Kukra, Lakhimpur (Kheri) U.P. (Uttar Pradesh), North India
36.	BKT-1	Bakshi-Ka-Talab Lucknow, U.P. (Uttar Pradesh), North India
37.	NMH-10	Nimach, M.P. (Madhya Pradesh), Central India
38.	TRICH-5	Trissur (Kerala), South India
39.	GANDHI-12	Gandhi Nagar, Gujrat, India
40.	MUSA-5	Musanagar, U.P. (Uttar Pradesh), North India

[a] Essential oil having – rosy note.
[b] Essential oil having – saffron note. Rest of all accessions having – khus/earthy note in their essential oil.

Morphological observations were recorded for seven economic characters, plant height (cm), tillers/plant, fresh and dry root (g)/plant, root length (cm), oil content (%) and oil yield/plant (g). Oil content was estimated by hydro-distillation of fresh roots from each genetic stock for 16 h in a Clevenger apparatus (Clevenger, 1928).

Pooled mean data over three years were statistically analyzed for mean ($\bar{X}$), standard error, ranges (Singh and Chaudhary, 1979), D^2-statistics and canonical analysis (Mahalanobis, 1936) according to for all the seven morpho-metric traits. The cluster formation was confirmed by Tocher's methods (Rao, 1952) and spatial distribution of genotypes in a λ_1–λ_2 chart. Heritability (broad sense) and genetic advance calculated by using following formula (Singh and Chaudhary, 1979):

Heritability (broad sense): it is the ratio of genotypic variance to the phenotypic variance:

$$h^2_{(bs)} = \frac{\sigma^2 g}{\sigma^2 p}$$

Table 2
Intra- and inter cluster divergence in Vetiver genetic stocks.

Clusters	I	II	III	IV	V	VI	$\bar{D}^2$	Genetic stocks included
I(21)	**304.25**	527.21	649.59	3061.25	4032.83	15,362.42	3989.59	4, 5, 6, 7, 8, 10, 15, 16, 18, 20, 21, 22, 23, 24, 25, 26, 31, 33, 34, 35, 37
	(17.44)	(22.96)	(25.49)	(55.33)	(63.50)	(123.95)	(63.16)	
II(12)		**311.40**	1216.35	3794.72	3630.10	14,380.61	3976.73	11, 12, 13, 14, 17, 19, 27, 28, 29, 30, 38, 39
		(17.65)	(34.88)	(61.60)	(60.50)	(119.92)	(63.06)	
III(3)			**173.64**	1555.50	4247.48	15,730.59	3928.86	9, 36, 40
			(13.18)	(39.44)	(65.17)	(125.42)	(62.68)	
IV(2)				**525.71**	3522.50	11,750.20	4034.98	1, 2
				(22.93)	(59.35)	(108.40)	(63.52)	
V(1)					**0.00**	4905.88	3389.80	3
						(70.04)	(58.22)	
VI(1)						**0.00**	10,354.95	32
							(101.76)	

Intra-cluster value in bold letters. $\bar{D}^2$ = Average D^2, $D = \sqrt{D^2}$ in parenthesis.