

# DNA fingerprints (RAPDs) of the pantropical grass vetiver, *Vetiveria zizanioides* (L.) Nash (Gramineae), reveal a single clone 'Sunshine' is widely utilized in erosion control<sup>1</sup>

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**Abstract:** Random Amplified Polymorphic DNAs (RAPDs) were used to examine accessions (n=121) of vetiver (*Vetiveria zizanioides* (L.) Nash) and related taxa from its region of origin and around the world. It appears only one *V. zizanioides* genotype, 'Sunshine', accounts for almost all germplasm utilized outside South Asia. Curiously, no 'Sunshine' types were detected from within this region of vetiver's early distribution. Additional RAPD analyses revealed that at least seven other non-fertile accessions are distinct genotypes. This germplasm diversity holds promise for reducing the vulnerable genetic uniformity in what is now essentially a pantropical monoculture of an economically and environmentally important plant resource. Evaluation trials of these accessions are planned. DNA from air-dried leaves was often found to be degraded beyond use (n=22). Material submitted for DNA analysis should be small (actively growing) leaves, harvested fresh and immediately placed into activated silica gel or other suitable drying agent.

## Introduction

Elite germplines of *Vetiveria zizanioides* (L.) Nash have long been cultivated throughout the tropics for their fragrant roots, which contain the essential Oil of Vetiver. This oil is clearly distinguished chemically and in commerce from Khus oil, which comes from natural (fertile) populations of *V. zizanioides* in the Ganges Plain of north India (CSIR, 1976). Populations of the Oil of Vetiver types have increased enormously in the past decade through vegetative reproduction for widespread plantings (over 100 countries) of hedges to stabilize soil and control waterflow.

One of the desirable features of most hedgerow (essential oil) vetiver is that it is non fertile (produces no seed or seeds do not produce viable seedlings), and so it must be propagated from cuttings (clumps of rootstock). Because it does not reproduce by seed, for centuries it has been a very well-behaved grass throughout the tropics and subtropics. It has not escaped cultivation or become a weed. However, the mere fact that it is always distributed by cuttings could lead to the widespread cultivation of a single clone. This could be extremely dangerous. An insect or disease adapted to a particular genotype could spread and decimate millions of erosion control terraces of vetiver. In order to investigate this concern, we assembled leaf materials from around the world and compared these accessions to known wild and related materials using RAPDs (DNA fingerprints).

Genetic variability was initially investigated by Kresovich et al. (1994), who reported on vetiver variation in the United States. They found RAPD patterns were very stable within clones, that the non fertile 'Huffman' and 'Boucard' cultivars were identical (>.99+), and that these were clearly distinct from the USDA PI 196257 seed introductions from north India (Simla, Punjab). Interestingly, they found that three samples of this USDA accession (#s 1,2,3), though similar, were genetically distinct from one-another. They concluded that RAPDs would be useful for identifying truly distinct sources of genetic diversity. Srifah et al. (in press) confirmed this

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in Thailand (where vetiver is ancient if not indigenous) by showing that RAPDs could easily distinguish among landrace "ecotypes".

### **Materials and methods**

The reader is referred to Adams et al. (in press) for DNA extraction and analyses. However, it should be noted that a number of the accessions that were merely air dried or shipped fresh did not yield any DNA or the DNA was so degraded that it could not be analyzed. In the future, material submitted for DNA analysis should be small (actively growing) leaves, picked fresh and immediately placed into activated silica gel or other suitable drying agent. Sampling kits are available from the authors (Dafforn).

### **Results and Discussion**

An initial screening of accessions (n=53) using 222 banding patterns found almost no variation among cultivated materials. The pattern obtained by primer 268 is typical of that obtained using primers 184, 239, 249, 327, and 346. Essentially no variation was detected in an initial twenty-seven accessions for outside south Asia, except for a quite-similar accession from Malawi.

A second series of accessions (n=68) were analyzed running only one highly discriminating primer (268). This analysis, while revealing additional variation in non fertile types, reinforced patterns that form several distinct genetic clusters. These groupings are validated by correspondence to botanical taxa and field observations (reports of fertility), see Table 1.

Of 60 total samples submitted from 29 countries outside south Asia, 53 (88%) were a single clone of *Vetiveria zizanioides*. At least two-thirds of these samples were first accessioned from traditional, in-country sources, i.e. oil producers, herbalists, botanical gardens, and other planted sites, and therefore may be considered representative of *ex situ* vetiver populations. Because vetiver is vegetatively propagated, it thus appears that one single essential-oil clone (which we are denoting as 'Sunshine' because of accession priority) is densely distributed throughout the tropics. Its introduction[s] was done certainly before WWII and most likely before this century. For instance, vetiver has been in the United States since at least the early 19th century, although the earliest authenticated germline identifications are currently 'Vallonia', South Africa, via Mauritius, c. 1900, M. Robert; 'Monto', Australia, 1930s, P. Truong; 'Sunshine', USA, 1960s, E. LeBlanc; and MY044693 & MY081268, Venezuela, 1982, O. Rodriguez; (information from Vetiver Network members). Such a consistent identity in a spatially and temporally scattered distribution implies that virtually all of the *Vetiveria zizanioides* outside South Asia could be the single 'Sunshine' genotype, which today certainly dominates soil stabilization and waterflow control usage.

### **Conclusions**

Based on DNA fingerprinting data, it appears that almost all the vetiver used for erosion control outside South Asia has been derived from a single genotype, which we call 'Sunshine'. Nevertheless, discontinuities of geographic and genetic patterns in our analysis imply much vetiver diversity awaits discovery. There is a critical need to screen other, reportedly non fertile vetivers to uncover additional germlines to diversify current and future plantings of this very important "hedge against erosion" (NRC, 1993). Especially needed are samples from areas on the periphery of south Asia, where vetiver has been cultivated for centuries. Common garden studies are planned using the divergent vetiver accessions in Table 2. Further promising germplasm needs to be accessioned and observed. The challenge is to assure the genetic diversity of cultivated vetiver, which is proving of immense importance to agricultural stabilization and civil engineering.

**Table 1. Preliminary classification of vetiver accessions by DNA fingerprinting**

A = pattern based on 6 primers: 184, 239, 249, 268, 327, and 346. B = pattern based only on primer 268.

Fertile codes: N = no, Y = yes, F = fully, L = low, + = confirmed, - = assumed, ? = unknown.

\* = botanically verified at the species level.

Type	Accession #	Lab #	Species; Source (other locations)	Fertile?
<i>Vetiveria zizanioides</i>				
<i>Vetiveria zizanioides</i> (L.) Nash Sunshine clone (S) (= Haiti, Monto, Boucard, Huffman, Vallonia)				
S <sup>A</sup>	VET-RPA-7655	7655	<i>V. zizanioides</i> ; Haiti, Massif de la Selle	N+
S <sup>A</sup>	VET-RPA-7659	7659	<i>V. zizanioides</i> ; Haiti, Marigot	N+
S <sup>A</sup>	VET-RPA-7660	7660	<i>V. zizanioides</i> ; Haiti, Jacmel	N+
S <sup>A</sup>	VET-RPA-7661	7661	<i>V. zizanioides</i> ; Haiti, Jacmel	N+
S <sup>A</sup>	VET-RPA-7663	7663	<i>V. zizanioides</i> ; Haiti, Massif de la Selle	N+
S <sup>A*</sup>	VET-PT-1A	7711	<i>V. zizanioides</i> cv. 'Monto'; Australia, Queensland	N+
S <sup>A*</sup>	VET-PT-1B	7712	<i>V. zizanioides</i> cv. 'Fiji'; Australia, Queensland (Fiji)	N+
S <sup>A*</sup>	VET-PT-1D	7714	<i>V. zizanioides</i> ; Australia, Queensland (Western Australia)	N+
S <sup>A*</sup>	VET-PT-1E	7715	<i>V. zizanioides</i> ; New Guinea	N+
S <sup>A</sup>	VET-RGG-PA-A	7719	<i>V. zizanioides</i> ; Panama, site A	N+
S <sup>A</sup>	VET-RGG-CR-A	7721	<i>V. zizanioides</i> ; Costa Rica, San Jose	N+
S <sup>A*</sup>	VET-MR-VAL1	7722	<i>V. zizanioides</i> cv. 'Vallonia'; South Africa, Natal	N+
S <sup>A</sup>	VET-OSR-1.0	7729	<i>V. zizanioides</i> ; Venezuela, Maracay (flowers some)	N+
S <sup>A</sup>	VET-DEKN-1001	7730	<i>V. zizanioides</i> ; Aneityum Island, Pacific	N+
S <sup>A</sup>	VET-DEKN-1003	7731	<i>V. zizanioides</i> ; Efate Island, Pacific	N+
S <sup>A</sup>	VET-DEKN-1002	7732	<i>V. zizanioides</i> ; Atiu Island, Pacific	N+
S <sup>A</sup>	VET-DEKN-1004	7733	<i>V. zizanioides</i> ; Mangaia Island, Pacific	N+
S <sup>A</sup>	VET-GVB-001	7742	<i>V. zizanioides</i> cv. 'Boucard'; USA, Texas, (Haiti or Guatemala)	N+
S <sup>A</sup>	VET-MJ-F1	7747	<i>V. zizanioides</i> ; USA, North Carolina	N+
S <sup>A</sup>	VET-MJ-F2	7748	<i>V. zizanioides</i> ; USA, North Carolina	N+
S <sup>A*</sup>	VET-MRL-0001	7749	<i>V. zizanioides</i> cv. 'Sunshine'; USA, Louisiana	N+
S <sup>A</sup>	VET-MRD-0001	7750	<i>V. zizanioides</i> cv. 'Sunshine'; USA, Louisiana	N+
S <sup>A</sup>	VET-MRD-0002	7751	<i>V. zizanioides</i> cv. 'Huffman'; USA, Florida (Louisiana)	N+
S <sup>A</sup>	VET-RDH-0001	7767	<i>V. zizanioides</i> ; Hong Kong (Thailand?)	N-
S <sup>A</sup>	VET-RDH-0002	7768	<i>V. zizanioides</i> ; Hong Kong (South China)	N-
S <sup>B</sup>	VET-JG-23	7773	<i>V. zizanioides</i> ; New Zealand, Northland	N
S <sup>B</sup>	VET-EB-5997	7776	<i>V. zizanioides</i> ; Netherlands Antilles, Bonaire (USA)	N
S <sup>B</sup>	VET-JGN-0001	7777	<i>V. zizanioides</i> ; USA, California	N+
S <sup>B</sup>	VET-EAB-5262	7950	<i>V. zizanioides</i> ; Philippines, Leyte	N
S <sup>B</sup>	VET-CXH-0001	7952	<i>V. zizanioides</i> ; China, Guiyang	N+
S <sup>B</sup>	VET-JA-1-1	7954	<i>V. zizanioides</i> ; Kenya, Nairobi, ICRAF	N
S <sup>B</sup>	VET-JA-1-3	7956	<i>V. zizanioides</i> ; Peru, Iquitos, ICRAF	N
S <sup>B</sup>	VET-JA-1-4	7957	<i>V. zizanioides</i> ; Peru, Iquitos, ICRAF	N
S <sup>B</sup>	VET-JA-2-3	7960	<i>V. zizanioides</i> ; Peru, Iquitos, ICRAF	N
S <sup>B</sup>	VET-OSR-1-B	7961	<i>V. zizanioides</i> ; Venezuela, Maracay (Carabobo)	N+
S <sup>B*</sup>	VET-OSR-2	7962	<i>V. zizanioides</i> ; Venezuela, Maracay (Bajo Seco)	N+
S <sup>B</sup>	VET-HGR-01	7965	<i>V. zizanioides</i> ; Colombia, Bogota	N+
S <sup>B</sup>	VET-TS-F1	7967	<i>V. zizanioides</i> ; Ethiopia, Filakit	N+
S <sup>B</sup>	VET-TS-F2	7968	<i>V. zizanioides</i> ; Ethiopia, Filakit	N+
S <sup>B</sup>	VET-TS-F3	7969	<i>V. zizanioides</i> ; Ethiopia, Filakit	N+
S <sup>B</sup>	VET-TS-D1	7970	<i>V. zizanioides</i> ; Ethiopia, Digitosh	N+
S <sup>B</sup>	VET-TS-D2	7971	<i>V. zizanioides</i> ; Ethiopia, Digitosh	N+
S <sup>B</sup>	VET-TS-M1	7973	<i>V. zizanioides</i> ; Ethiopia, Minikaba	N+
S <sup>B</sup>	VET-TS-M2	7974	<i>V. zizanioides</i> ; Ethiopia, Minikaba	N+
S <sup>B</sup>	VET-TS-M3	7975	<i>V. zizanioides</i> ; Ethiopia, Minikaba	N+
S <sup>B</sup>	VET-HP-01	7986	<i>V. zizanioides</i> ; Honduras, Zamorano	N
S <sup>B</sup>	VET-HP-03	7988	<i>V. zizanioides</i> ; USA, Florida (Louisiana)	N
S <sup>B</sup>	VET-JMJS-VC1	8000	<i>V. zizanioides</i> ; Mexico, Oaxaca (Vera Cruz)	N
S <sup>B</sup>	VET-CED-0001	8002	<i>V. zizanioides</i> ; Bolivia, Sucre (MASDAR germplasm?)	N
S <sup>B</sup>	VET-DD-A1	8005	<i>V. zizanioides</i> ; Ethiopia, Dilla, Gedio	N
S <sup>B</sup>	VET-DD-B1	8006	<i>V. zizanioides</i> ; Ethiopia, Dilla, Gedio	N
S <sup>B</sup>	VET-DD-C1	8007	<i>V. zizanioides</i> ; Ethiopia, Dilla, Gedio	N
S <sup>B</sup>	VET-MB-01	8029	<i>V. zizanioides</i> cv. 'Huffman'; USA, Florida (Louisiana)	N+
Sunshine affinities: (S- = Sunshine pattern with one missing band, S+ = Sunshine pattern with one additional band).				
S <sup>+B</sup>	VET-IPA-MUIR-001	7989	<i>V. zizanioides</i> ; Mozambique, Maputo	?
S <sup>+B</sup>	VET-LW-0001	8048	<i>V. zizanioides</i> cv. 'Capitol'; USA, Louisiana	N
S <sup>-B*</sup>	VET-TGAVC-002	8051	<i>V. zizanioides</i> cv. 'AVC'; Spain, Murcia (Malaysia, India?)	N+

Sri Lanka (Chiapas) clone (SL):				
SL <sup>B*</sup>	VET-RN-001	7951	<i>V. zizanioides</i> ; Sri Lanka, Colombo	N-
SL <sup>B</sup>	VET-IMZ-AGA	7765	<i>V. zizanioides</i> ; Malawi, Lilongwe	N-
SL <sup>B</sup>	VET-SBR-VNN-96/2	7993	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N-
SL <sup>B</sup>	VET-SBR-VNN-96/3	7994	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N-
SL <sup>B</sup>	VET-SBR-VNN-96/4	7995	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N-
SL <sup>B</sup>	VET-SBR-AN-96/2	7997	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N-
SL <sup>B</sup>	VET-SBR-AN-96/4	7999	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N-
SL <sup>B</sup>	VET-JMJS-CH1	8001	<i>V. zizanioides</i> ; Mexico, Oaxaca (Chiapas)	N-
'Farmers Fodder' or 'Karnataka' (KM)				
KM <sup>B*</sup>	VET-TGKN-003	8052	<i>V. zizanioides</i> cv. 'Karnataka'; Spain, Murcia (Malaysia, India)	N+
'Breeder' complex (G):				
G <sup>B*</sup>	VET-UCL-027	7981	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	L?
G <sup>B*</sup>	VET-HP-02	7987	<i>V. zizanioides</i> ; India, Uttar Pradesh, (USDA PI 554617, 'Carter')	YL
'Breeder' affinities: G+, G++ = with one(+) or two (++) extra band(s); G- = with a missing band.				
G+ <sup>B</sup>	VET-JGN-0002	7778	<i>V. zizanioides</i> ; USA, California (Philippines?)	YL?
G++ <sup>B*</sup>	VET-UCL-024	7980	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
G+ <sup>B*</sup>	VET-UCL-040	7982	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
G- <sup>B*</sup>	VET-UCL-042	7983	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
G+ <sup>B*</sup>	VET-UCL-045	7984	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
G+ <sup>-B*</sup>	VET-UCL-M1	7985	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
Khus type of Northern India (Kh): (similar to Indian type I, cf. 7761)				
Kh <sup>B*</sup>	VET-SCRC-001	8035	<i>V. zizanioides</i> ; USA, USDA (India)	YF+
'Ganges' complex (North India), loose group with considerable banding differences.				
I <sup>B*</sup>	VET-BANG-B001	7723	<i>V. zizanioides</i> ; Bangladesh	YF+
I <sup>B*</sup>	VET-BANG-B002	7724	<i>V. zizanioides</i> ; Bangladesh	YF+
I <sup>B*</sup>	VET-BANG-B003	7725	<i>V. zizanioides</i> ; Bangladesh	YF+
I <sup>B*</sup>	VET-BANG-B004	7726	<i>V. zizanioides</i> ; Bangladesh	YF+
I <sup>B*</sup>	VET-USDA-U1	7735	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF+
I <sup>B*</sup>	VET-USDA-U2	7736	<i>V. zizanioides</i> ; India, A-3225 (USDA PI 213903)	YF+
I <sup>B*</sup>	VET-USDA-U3	7737	<i>V. zizanioides</i> ; India (USDA PI 271633)	YF+
I <sup>B*</sup>	VET-USDA-U4	7738	<i>V. zizanioides</i> ; India, A-7026 (unverified) (USDA PI 302300)	YF+
I <sup>B*</sup>	VET-USDA-U5	7739	<i>V. zizanioides</i> ; India, NBPGR Hybrid 7 (USDA PI 538753)	YF+
I <sup>B*</sup>	VET-USDA-U6	7740	<i>V. zizanioides</i> ; India, BE-2668, NBPGR Hybrid 8 (USDA PI 538754)	YF+
I <sup>B*</sup>	VET-USDA-U7	7741	<i>V. zizanioides</i> ; India, BE-2668, NBPGR Hybrid 26 (USDA PI 538756)	YF+
I <sup>B</sup>	VET-K-Dtp-1	7752	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-K-Pub-2	7753	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-K-Dnk-3	7754	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-K-Brk-8	7759	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-U-Blp-9	7760	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-U-Nlg-10	7761	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-U-Gsg-11	7762	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-U-Bdm-12	7763	<i>V. zizanioides</i> ; India, Orissa	YF+
I <sup>B</sup>	VET-CWDS-01	7764	<i>V. zizanioides</i> ; Nepal, Kathmandu (lowlands) (low flowering)	?
I <sup>B*</sup>	VET-UCL-005	7976	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
I <sup>B*</sup>	VET-UCL-007	7978	<i>V. zizanioides</i> ; India, Lucknow, CIMAP	?
I <sup>B*</sup>	VET-BANG-B006-B	8037	<i>V. zizanioides</i> ; Bangladesh	YF+
Ganges affinities: I- = Ganges type with one missing band:				
I- <sup>B*</sup>	VET-BANG-B005-B	8036	<i>V. zizanioides</i> ; Bangladesh	YF+
I- <sup>B*</sup>	VET-TGSB-004	8053	<i>V. zizanioides</i> cv. 'Sabah'; Spain, Murcia (Malaysia, India?)	N+
I- <sup>B*</sup>	VET-TGSBB-005	8054	<i>V. zizanioides</i> cv. 'Sabik Bern', Spain, Murcia (Malaysia, India?)	N+
Grafton type (Gr):				
Gr <sup>A*</sup>	VET-PT-1C	7713	<i>V. zizanioides</i> cv. 'Grafton'; Australia, Queensland	YL+
Gr <sup>B</sup>	VET-SBR-AN-96/1	7996	<i>V. zizanioides</i> ; Sri Lanka, Kandy	?
Other <i>V. zizanioides</i> banding patterns (O): (various banding, each of which is different)				
O <sup>B</sup>	VET-SJC-2	7775	<i>V. zizanioides</i> ; Malawi, Zomba	N+
O <sup>B*</sup>	VET-TGML-001	8050	<i>V. zizanioides</i> cv. 'Malaysia'; Spain, Murcia (Malaysia, India?)	N+
O <sup>B*</sup>	VET-TGPB-006	8055	<i>V. zizanioides</i> cv 'Parit Bunt'; Spain, Murcia (Malaysia, India?)	N+
O <sup>I</sup>	VET-JM-1V1	8076	<i>V. zizanioides</i> ?; Costa Rica, Puerto Viejo	N?

## Other species

<i>V. elongata</i> (R. Br.) Stapf (Eg): (very similar to one another)				
Eg <sup>A*</sup>	VET-PT-2A	7716	<i>V. elongata</i> (narrow leaf); Australia, Northern Territory	YF-
Eg <sup>A*</sup>	VET-PT-2B	7717	<i>V. elongata</i> (broad leaf); Australia, Northern Territory	YF-
<i>V. filipes</i> (Benth.) C.E.Hubb. (Fp) (quite distinct, 7772 may be a different species or genus)				
Fp <sup>B*</sup>	VET-PT-2C	7718	<i>V. filipes</i> ; Australia	YF-
Fp <sup>B*</sup>	VET-FA-257810	7772	<i>V. filipes</i> ; Australia, USDA PI 257810	YF+
<i>V. nigrimana</i> (Benth.) Stapf (Ng): (very similar to one another)				
Ng <sup>A</sup>	VET-ISV-AGA	7766	<i>V. nigrimana</i> ; Malawi, Lilongwe (few seed)	YL?!
Ng <sup>B</sup>	VET-SJC-1	7774	<i>V. nigrimana</i> ; Malawi, Zomba	YF+
Possible other <i>Vetiveria</i> / <i>Chrysopogon</i> species <sup>1</sup>				
P <sup>A</sup>	VET-RGG-PA-B	7720	<i>Vetiveria</i> sp.?; Panama, Western, site B (Costa Rica)	?
Vb <sup>B</sup>	VET-BANG-B005	7727	<i>Vetiveria</i> sp.?; Bangladesh	YF+?
Vb <sup>B</sup>	VET-BANG-B006	7728	<i>Vetiveria</i> sp.?; Bangladesh	YF+?
Other Genera:				
<i>Chrysopogon</i> Trin.				
Cf <sup>A*</sup>	VET-CFP-219579	7769	<i>C. fulvus</i> (Spreng.) Chiov.; Pakistan (USDA PI 219579)	YF
Cg <sup>A*</sup>	VET-CGP-383762	7771	<i>C. gryllus</i> (L.) Trin.; Turkey (USDA PI 383762)	YF
Ca <sup>B*</sup>	VET-BANG-B007	8038	<i>C. aciculatus</i> (Retz.) Trin.; Bangladesh	YF+
Cn <sup>B*</sup>	VET-JVTH-ZN001	8040	<i>Chrysopogon nemoralis</i> (Balansa) Holttum (recvd as <i>Zizania nemoralis</i> (Balansa) Camas); Thailand	Y?F?
<i>Sorghum</i> Moench.				
Sh <sup>A*</sup>	VET-AW-01	8030	<i>S. halepense</i> (L.) Pers.; USA, Texas	YF+
Sb <sup>A*</sup>	VET-RPA-8030	8030	<i>S. bicolor</i> (L.) Moench.; USA, Texas	YF+

## Not tested

(NT = not tested; D = degraded DNA, see text)

NT	VET-MJ-B1	7701	<i>V. zizanioides</i> ; USA, North Carolina, fungus on seeds	
NT	VET-MJ-B2	7702	<i>V. zizanioides</i> ; USA, North Carolina, fungus on seeds	
NT	VET-MJ-B3	7703	<i>V. zizanioides</i> ; USA, North Carolina, fungus on seeds	
NT	VET-MJ-B4	7704	<i>V. zizanioides</i> ; USA, North Carolina, fungus on seeds	
NT	VET-MJ-B5	7705	<i>V. zizanioides</i> ; USA, North Carolina, fungus on seeds	
NT*	VET-USDA-F1	7734	<i>V. filipes</i> ; Australia, USDA (PI 257810) (duplicate acc. under 7772)	YF+
NT	VET-K-Bdln-4	7755	<i>Vetiveria</i> sp.; India, Orissa	YF+
NT	VET-K-Bdln-5	7756	<i>Vetiveria</i> sp.; India, Orissa	YF+
NT	VET-K-Bdln-6	7757	<i>Vetiveria</i> sp.; India, Orissa	YF+
NT	VET-K-Bdln-7	7758	<i>Vetiveria</i> sp.; India, Orissa	YF+
NT	VET-JSC-0001	7953	<i>V. zizanioides</i> ?; Cambodia (Australia)	?
NT	VET-JBH-1267	8039	<i>C. schmidianus</i> ; Laos	?
D*	VET-USDA-B6	7706	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B7	7707	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B8	7708	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B9	7709	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-USDA-B10	7710	<i>V. zizanioides</i> ; India, Punjab, Simla (USDA PI 196257)	YF
D*	VET-CFI-554618	7770	<i>C. fulvus</i> (Sprengel) Chiov.; India (USDA PI 554618)	YF
D	VET-EAB-5261	7949	<i>V. zizanioides</i> ; Philippines, Leyte	?
D	VET-JA-1-2	7955	<i>V. zizanioides</i> ; Kenya, Nairobi, ICRAF	?
D	VET-JA-2-1	7958	<i>V. zizanioides</i> ; Kenya, Nairobi, ICRAF	?
D	VET-JA-2-2	7959	<i>V. zizanioides</i> ; Kenya, Nairobi, ICRAF	?
D	VET-NSC-01	7963	<i>V. zizanioides</i> ; Cameroon, Mbingo Bamenda (Nigeria)	?
D	VET-NSC-02	7964	<i>V. zizanioides</i> ; Cameroon, Maroua	?
D*	VET-HGR-02	7966	<i>V. zizanioides</i> ; Colombia, Cundinamarca (flowering)	?
D	VET-TS-D3	7972	<i>V. zizanioides</i> ; Ethiopia, Digitosh	N+
D*	VET-UCL-006	7977	<i>V. zizanioides</i> ; India, CIMAP	?
D*	VET-UCL-008	7979	<i>V. zizanioides</i> ; India, CIMAP	?
D	VET-SBR-VA-96/1	7990	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N?
D	VET-SBR-VH-96/1	7991	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N?
D	VET-SBR-VNN-96/1	7992	<i>V. zizanioides</i> ; Sri Lanka, Kandy	N?
D	VET-SBR-AN-96/3	7998	<i>V. zizanioides</i> ; Sri Lanka, Kandy	?
D	VET-BBG-001	8003	<i>V. zizanioides</i> ; Ghana, Central	N+
D	VET-BBG-02	8004	<i>V. fulvibarbus</i> ; Ghana, Central	N+

<sup>1</sup> All three of these samples are anomalous; these results are presented to maintain the completeness of data presentation. VET-RGG-PA-B ('Panama B'), currently under curation in Costa Rica, falls well outside the variability shown in the *Sorghum/Vetiveria/Chrysopogon* complex; nonetheless, to experienced eyes it has the morphology of *V. zizanioides* (information from The Vetiver Network, [vetiver@vetiver.org](mailto:vetiver@vetiver.org)). The two Bengali specimens also fall outside the range of other samples, most likely due to handling error or contamination (for which the authors apologize).

**Table 2. *Vetiveria zizanioides* germplasm of high priority for maintenance and evaluation.**

Type	Accession #	Lab #	Species; Source (other locations)	Fertile?
S <sup>A</sup>	VET-PT-1A	7711	<i>V. zizanioides</i> cv. 'Monto'; Australia, Queensland	N+
S <sup>A</sup>	VET-MR-VAL1	7722	<i>V. zizanioides</i> cv. 'Vallonia'; South Africa	N
S <sup>A</sup>	VET-GVB-001	7742	<i>V. zizanioides</i> cv. 'Boucard'; USA, Texas	N+
S <sup>B</sup>	VET-MRL-001	7749	<i>V. zizanioides</i> cv. 'Sunshine'; USA, Louisiana	N
S <sup>B</sup>	VET-MB-01	8029	<i>V. zizanioides</i> cv. 'Huffman'; USA, Florida	N+
S <sup>B</sup>	VET-OSR-1-B	7961	<i>V. zizanioides</i> ; Venezuela, Maracay (Carabobo)	N+
S <sup>+B</sup>	VET-IPA-MUIR-001	7989	<i>V. zizanioides</i> ; Mozambique, Maputo	?
S <sup>+B</sup>	VET-LW-0001	8048	<i>V. zizanioides</i> cv. 'Capitol'; USA, Louisiana	N
S <sup>-B</sup>	VET-TGAVC-002	8051	<i>V. zizanioides</i> cv. 'AVC'; Spain, Murcia (Malaysia, India?)	N+
SL <sup>B</sup>	VET-IMZ-AGA	7765	<i>V. zizanioides</i> ; Malawi, Lilongwe	?!
SL <sup>B</sup>	VET-RN-001	7951	<i>V. zizanioides</i> ; Sri Lanka, Colombo	N+?
SL <sup>B</sup>	VET-JMJS-CHI	8001	<i>V. zizanioides</i> ; Mexico, Oaxaca (Chiapas)	N+?
CR <sup>B</sup>	VET-JM-PV1	8076	<i>V. zizanioides</i> ?; Costa Rica, Puerto Viejo	N?
Gr <sup>A</sup>	VET-PT-1C	7713	<i>V. zizanioides</i> cv. 'Grafton'; Australia, Queensland	YL+
Gr <sup>B</sup>	VET-SBR-AN-96/1	7996	<i>V. zizanioides</i> ; Sri Lanka, Kandy	?
G <sup>+B</sup>	VET-JGN-0002	7778	<i>V. zizanioides</i> ; USA, California (Philippines?)	YL?
KM <sup>B</sup>	VET-TGKN-003	8052	<i>V. zizanioides</i> cv. 'Karnataka'; Spain, Murcia (Malaysia, India)	N+
G <sup>B</sup>	VET-HP-02	7987	<i>V. zizanioides</i> ; India, Uttar Pradesh, (USDA PI 554617, 'Carter')	YL+
P <sup>A</sup>	VET-RGG-PA-B	7720	<i>Vetiveria</i> sp.?; Panama, Western, site B (Costa Rica)	?
O <sup>B</sup>	VET-SJC-2	7775	<i>V. zizanioides</i> ; Malawi, Zomba (few seed heads)	?
O <sup>B</sup>	VET-TGML-001	8050	<i>V. zizanioides</i> cv. 'Sabik Bern'; Spain, Murcia (Malaysia, India?)	N+
I <sup>-B*</sup>	VET-TGSB-004	8053	<i>V. zizanioides</i> cv. 'Sabah'; Spain, Murcia (Malaysia, India?)	?
I <sup>-B*</sup>	VET-TGSBB-005	8054	<i>V. zizanioides</i> cv. 'Sabik Bern'; Spain, Murcia (Malaysia, India?)	?
O <sup>B</sup>	VET-TGPB-006	8055	<i>V. zizanioides</i> cv. 'Sabik Bern'; Spain, Murcia (Malaysia, India?)	N+

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