VETIVER IN INDIA

Prospective for Development of Application Specific non-invasive Genotypes

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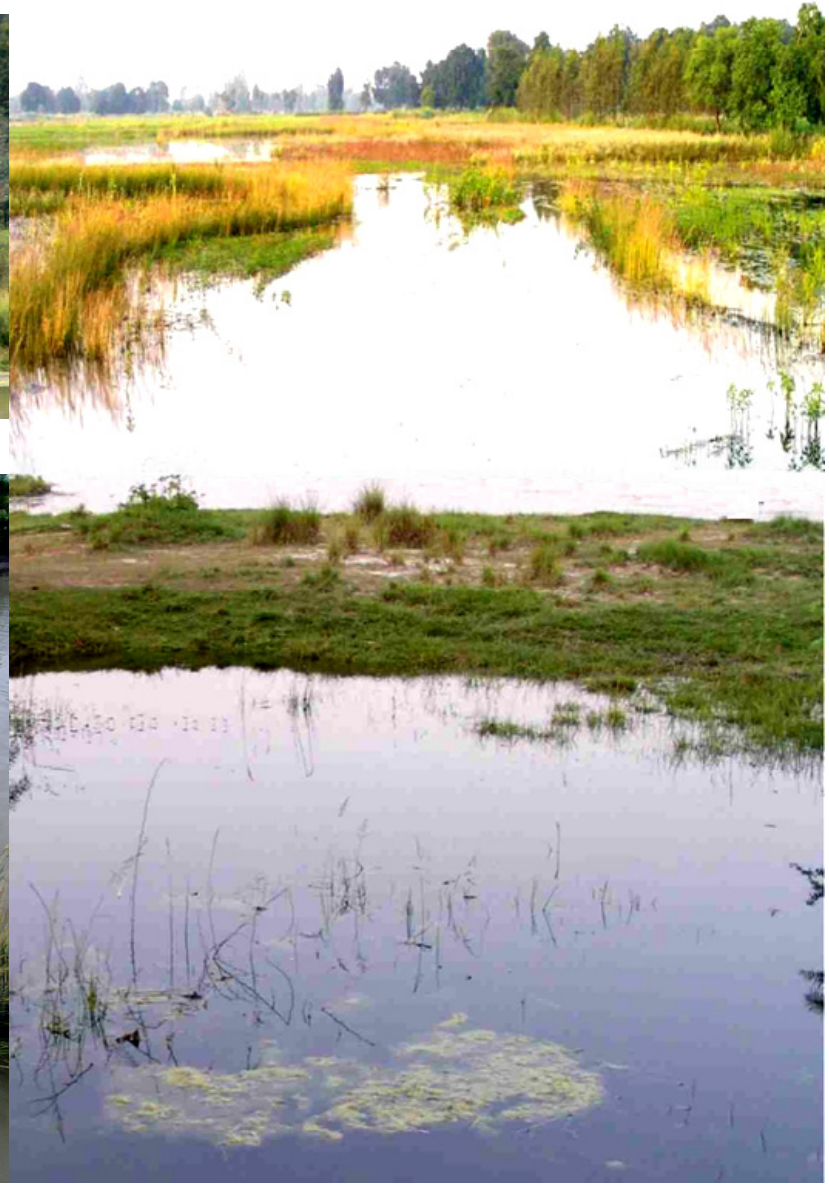
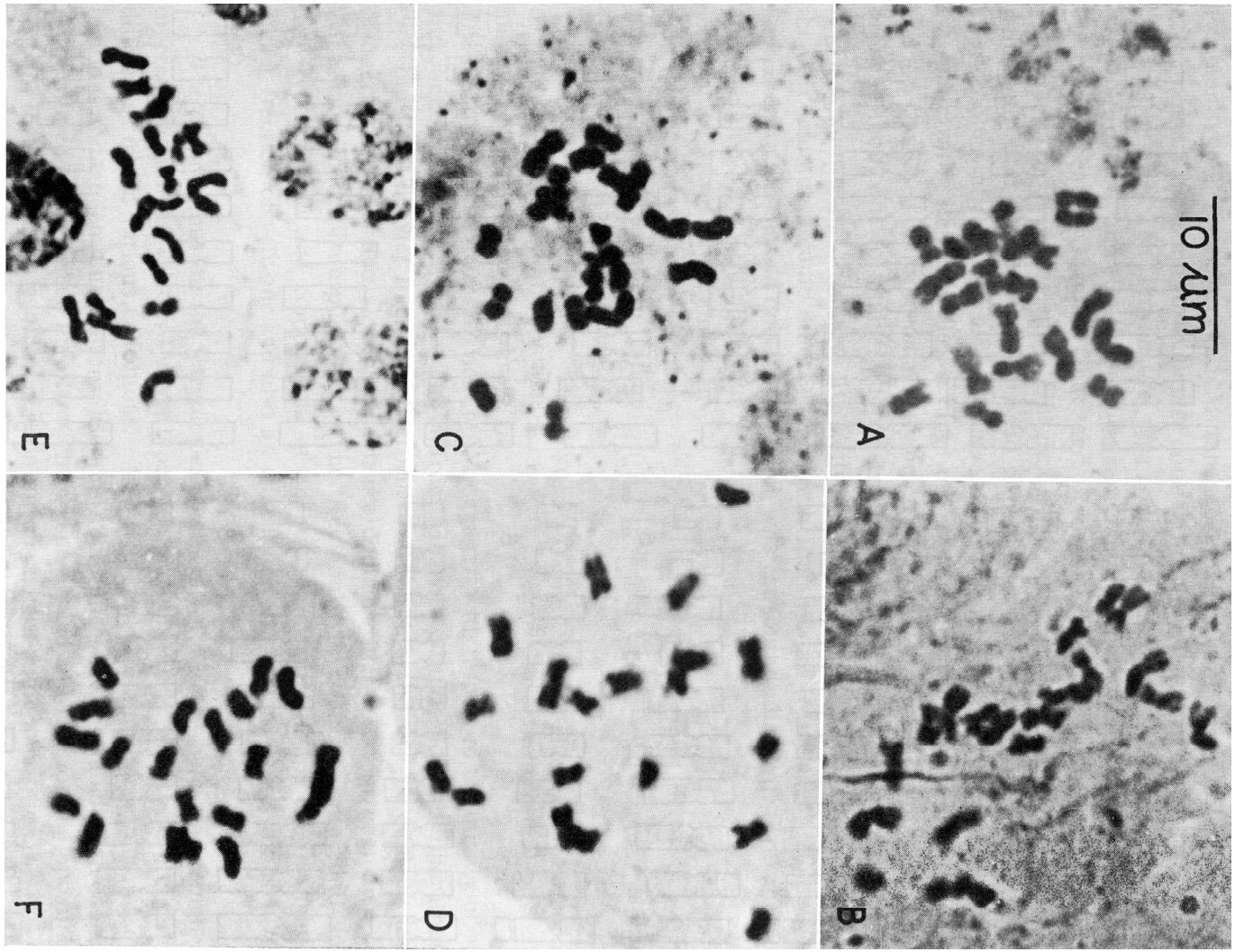


PROSPECTIVES OF VETIVER IN INDIA

- Vetiver is native to India, has been in traditional use since ancient times for its perfumery oil and contour protection by its hedges
- India is the Centre of Origin of Vetiver, and is thus enriched with repertoire of natural diversity suitable for scoring ideal plant type
- Inherent heterozygosity expressed through segregating seed progenies promises genetic diversity

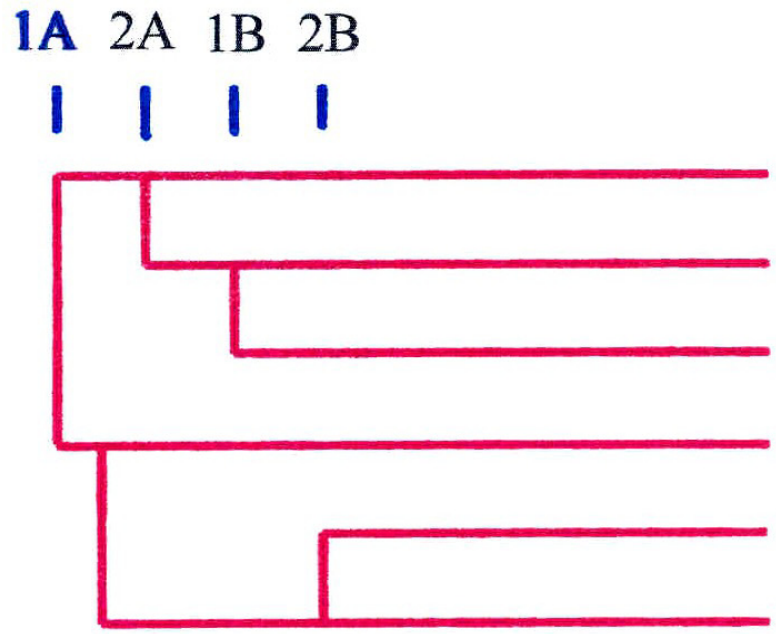
Karyomorphological diversity in Vetiver

Lavania, UC (1985) Cytologia 50 : 177-185



Range of diversity : Haploid chromatin length =29 – 33 µm, 2C DNA = 2.0 – 2.56pg

Chromosome diversity based delineation of origin and dispersion of Vetiver



Primary Centre

South India

North-West India

North-Central India

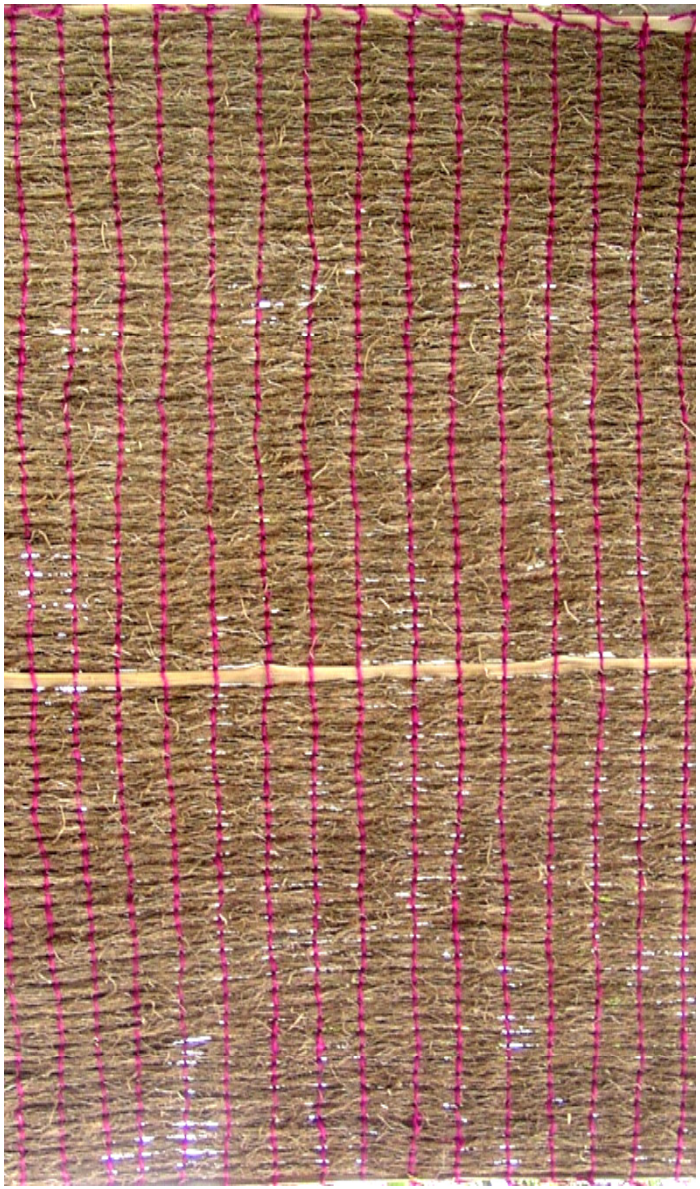
Secondary Centre

South Asia

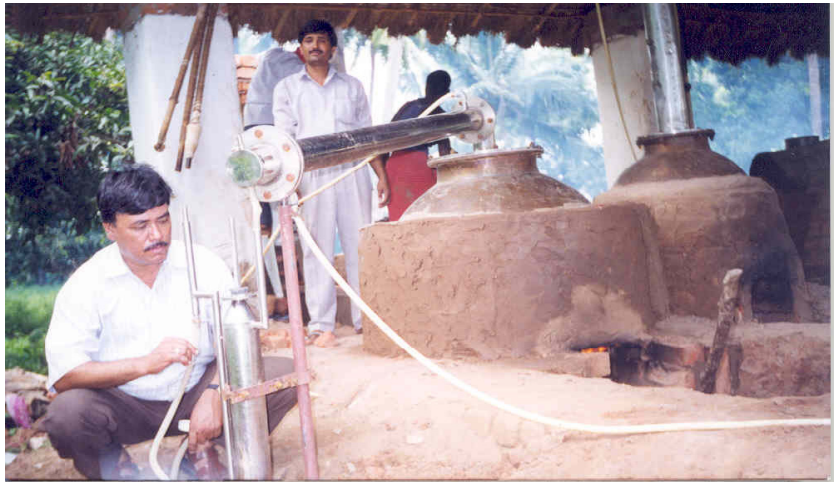
Karyotype symmetry

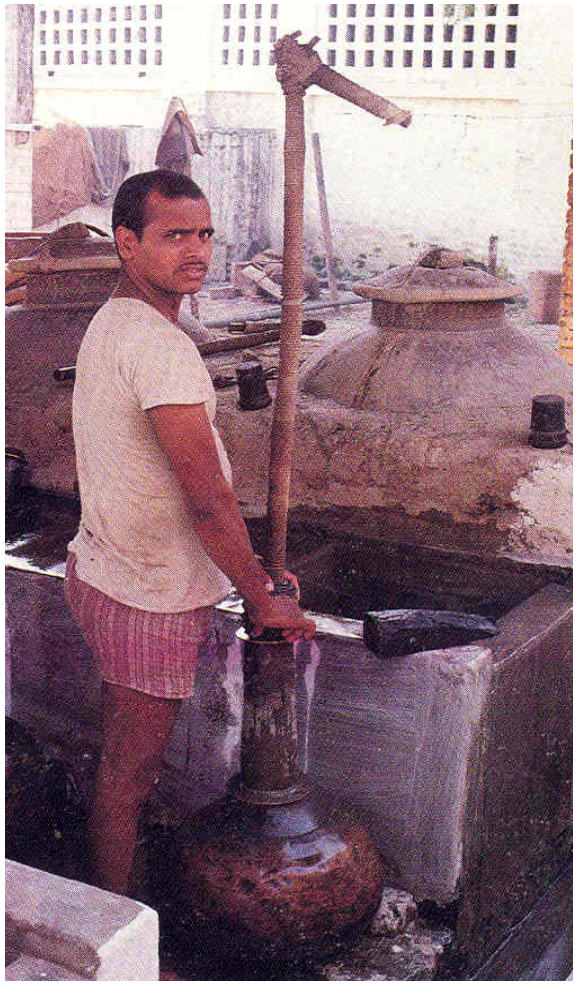
Karyoevolutionary differentiation

Utility products made from vetiver dry roots

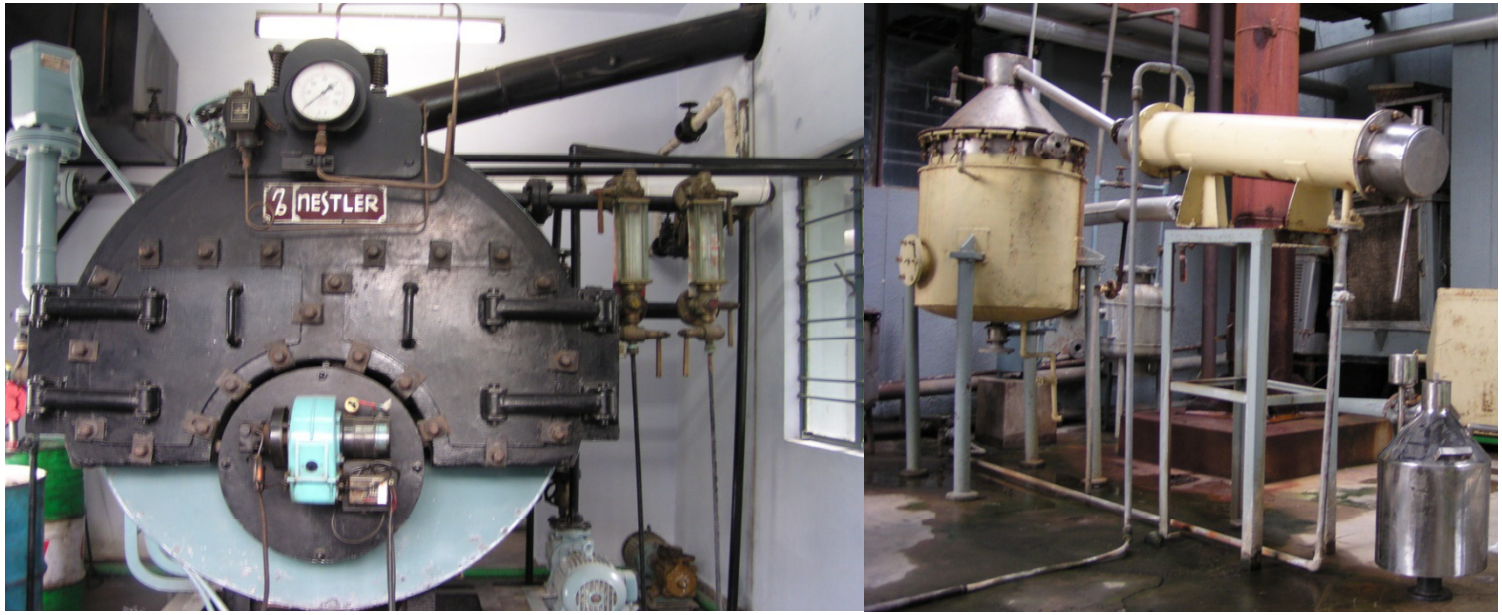


Traditional wood fired "*Deg-Bhapka*" distillation of vetiver oil





Modern Steam Distillation Unit



Vetiver root Oil

Annual World Production of Vetivert Oil	250 tons
Estimated oil price	US $ 80 / kg
Major Oil Producing countries	Haiti, Indonesia (Java), China, India, Brazil, Japan
Major Consumers	USA, Europe (France), India, Japan
Major Uses	Perfumery (Perfume, Blending, Fixative), Flavors, Cosmetics, Masticatories
Roots as such	Multifarious refrigerating applications

Geographical variation and qualitative differentiation in vetiver oil

Region	Perfumery Note	ORD	Price /Kg	Utilization
North India (wild Khus)	Sweet- Balsamic / Woody also Roseate , Saffron	-ve	US $ 250	High grade perfume
South India (cultivated vetiver)	Earthy	+ve	US $ 80	Fixative
Haiti & Bourbon	Roseate	+ve	US $ 100	Fixative, Blending
Others	Earthy , Woody	+ve	US $ 80	Fixative, Blending

Chemical composition *vis-à-vis* applications of vetiver oil

A complex oil comprising ~100 sesquiterpene type compounds belonging to 11 structural classes

Main constituents

Hydrocarbons	**γ-cadenene, clovene, α-amorphine, aromadendrine, junipene**
Alcohol derivatives (vetiverols):	**khusimol, epiglobulol, spathulenol, khusinol, khusilal (unique to north Indian vetiver)**
Carbonyl derivatives (vetivones):	**α-vetivone, β-vetivone, khusimone**
Ester derivative	**khusinol acetate.**

Chemical composition *vis-à-vis* applications of vetiver oil

Perfumery Applications

Pure oil (perfume in its own right)	**Base note with slow evaporation rate e.g. Ruh Khus, Majmua**
Vetiverol	**Weak aroma and high solubility in alcohols, renders best fixative and blending qualities**
Diluted forms	**flavoring, refreshing and refrigerating applications. e.g. "Vetiver pour Homme" and "Vetivert"**
Medicinal	**Aromatherapy : skin care, CNS benefits Useful in bleeding nose and bee stings**

Vetiver is traditionally used for extraction of essential oil from roots

We need genotypes that produce high concentration and superior quality of essential oil in their roots

Vetiver is now extensively utilized for its multifarious environmental applications

We need plant types that produce (i) low oil / virtually no oil in its roots that works as a deterrent to local root diggers, (ii) ideal root physiography suiting to desired application

Vetiver Root System

Vetiver Root System has diverse applications

- Source of Essential Oil
- Water and Soil Reclamation
- Detoxification and Pollution Mitigation
- Land / Slope Stabilization
- Bio-Engineering
- Environment Specific Cultivation

Each Application envisages specific type of root system

- Hence there is need to search for Ideal Root Type for specific applications

Organization of Vetiver Root System

- Tufted vertically growing root system
- Primary roots are supported with secondary fibrous roots
- Juvenile primary / secondary roots are solid with persistent cortex and little oil
- Mature thick roots are spongy with schizogenous cortex and well developed phloem
- Bast region is the site of Essential Oil synthesis and storage
- Solid vascular cylinder provides tensile strength to roots
- Schizogenous cortex facilitates root aeration suitable for submerged conditions

Diversity in Vetiver Plant System

Reproductive

- Profuse flowering – late flowering – low flowering – no flowering
- Seed forming to Sterile

Organizational

- Tremendous diversity in root structural organization
- Root growth pattern – vertical deep growth to spreading type
- Diversity in root-thickness and branching pattern
- Smooth –to-fibrous-anastomosising root mass

Physiological

- Physiochemical absorption potential to agricultural and toxic residues
- Tolerance to range of soil climates

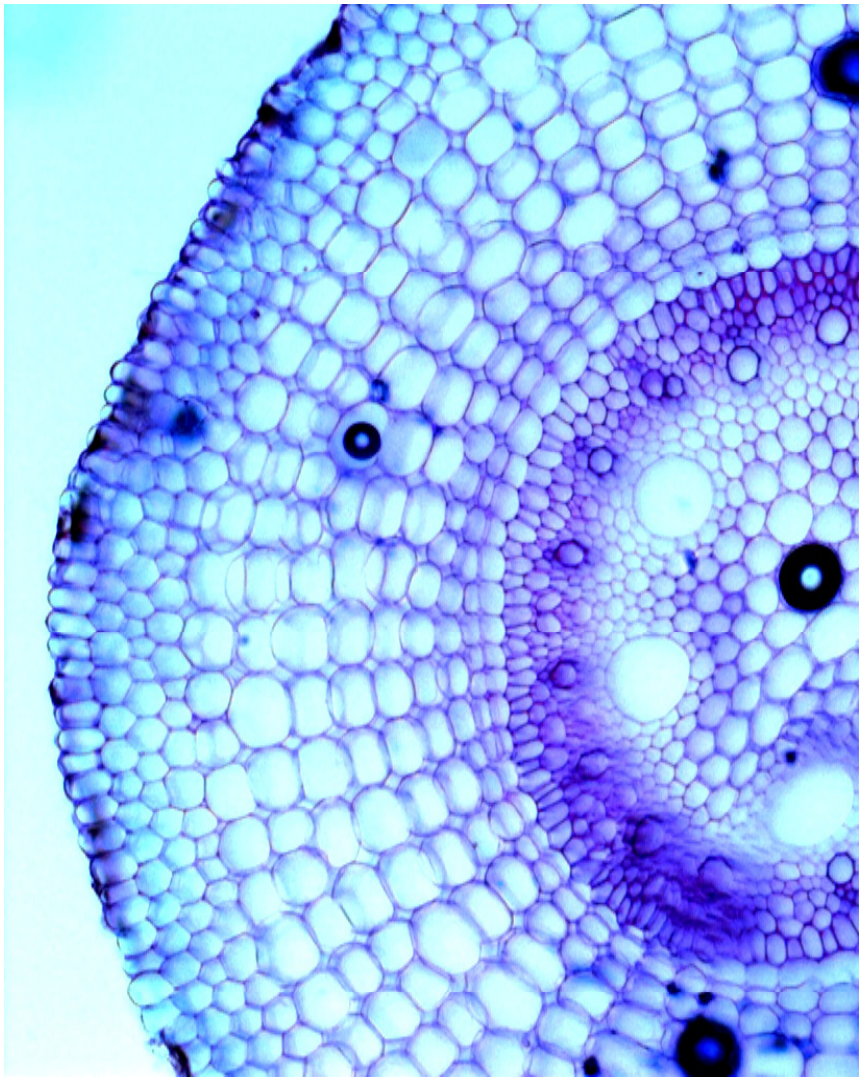
Flowering and Stigmatic Diversity

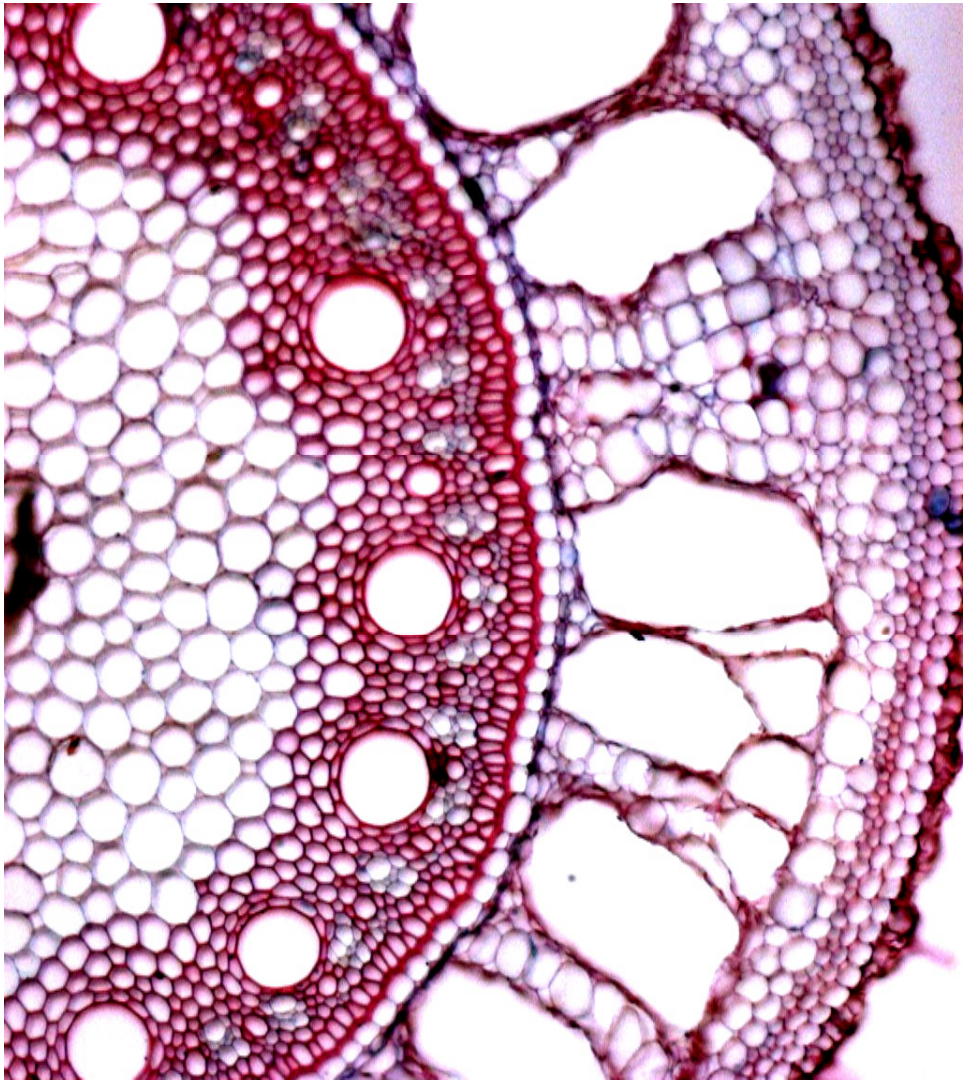
V. zizanioides (wild type - *Khus*)

V. nigritiana

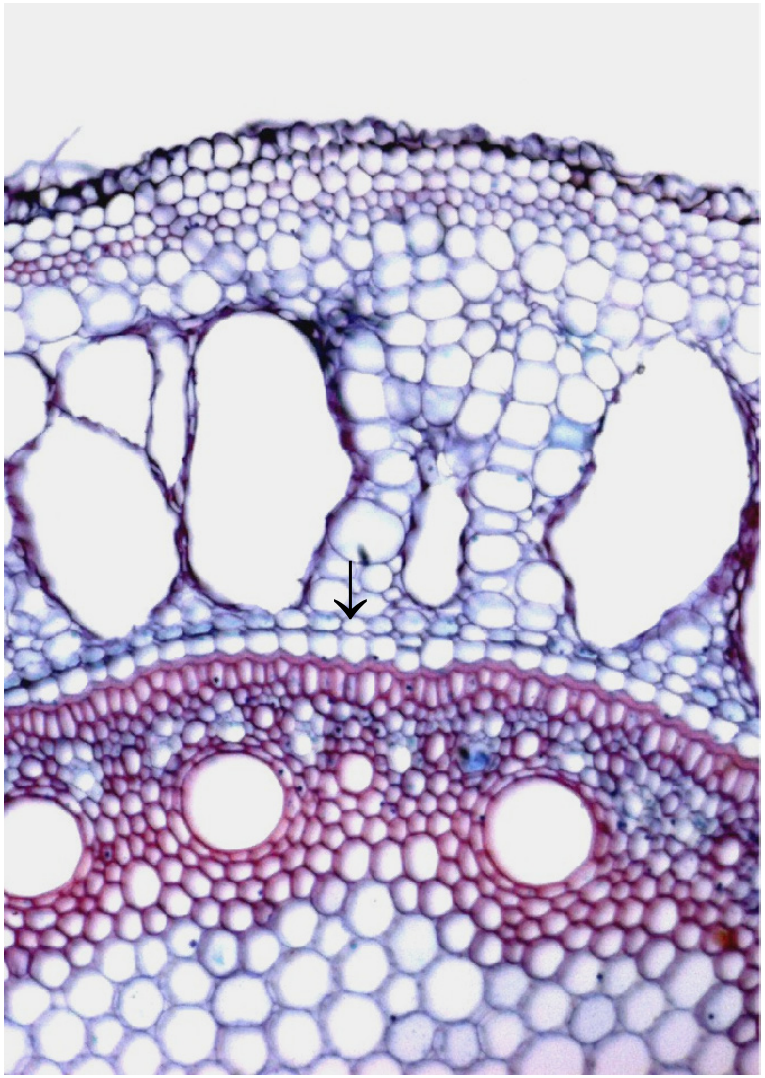
Vetiver root physiography diversity

Root cross section : young *vs.* mature root

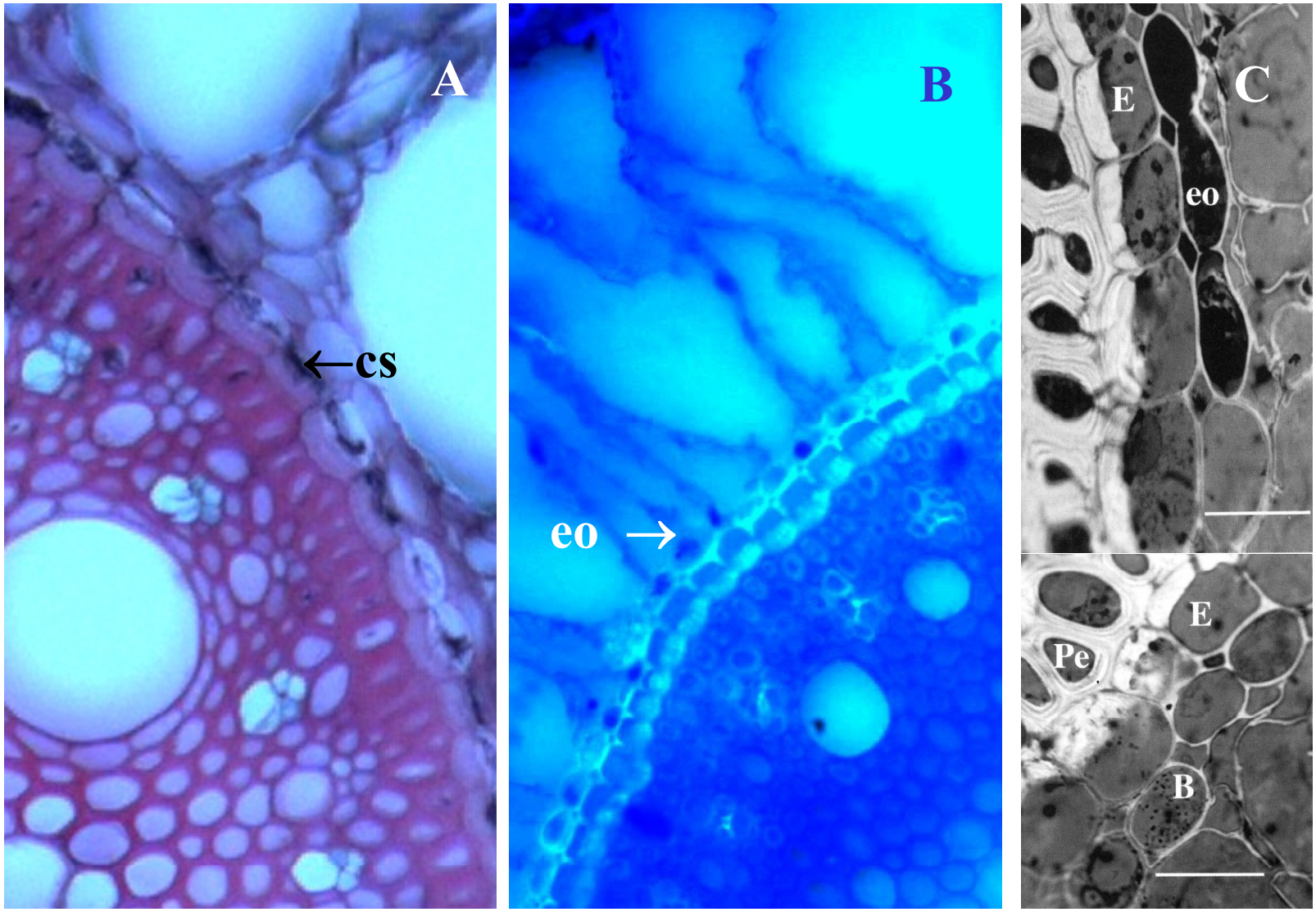




Root cross section showing endodermis diversity

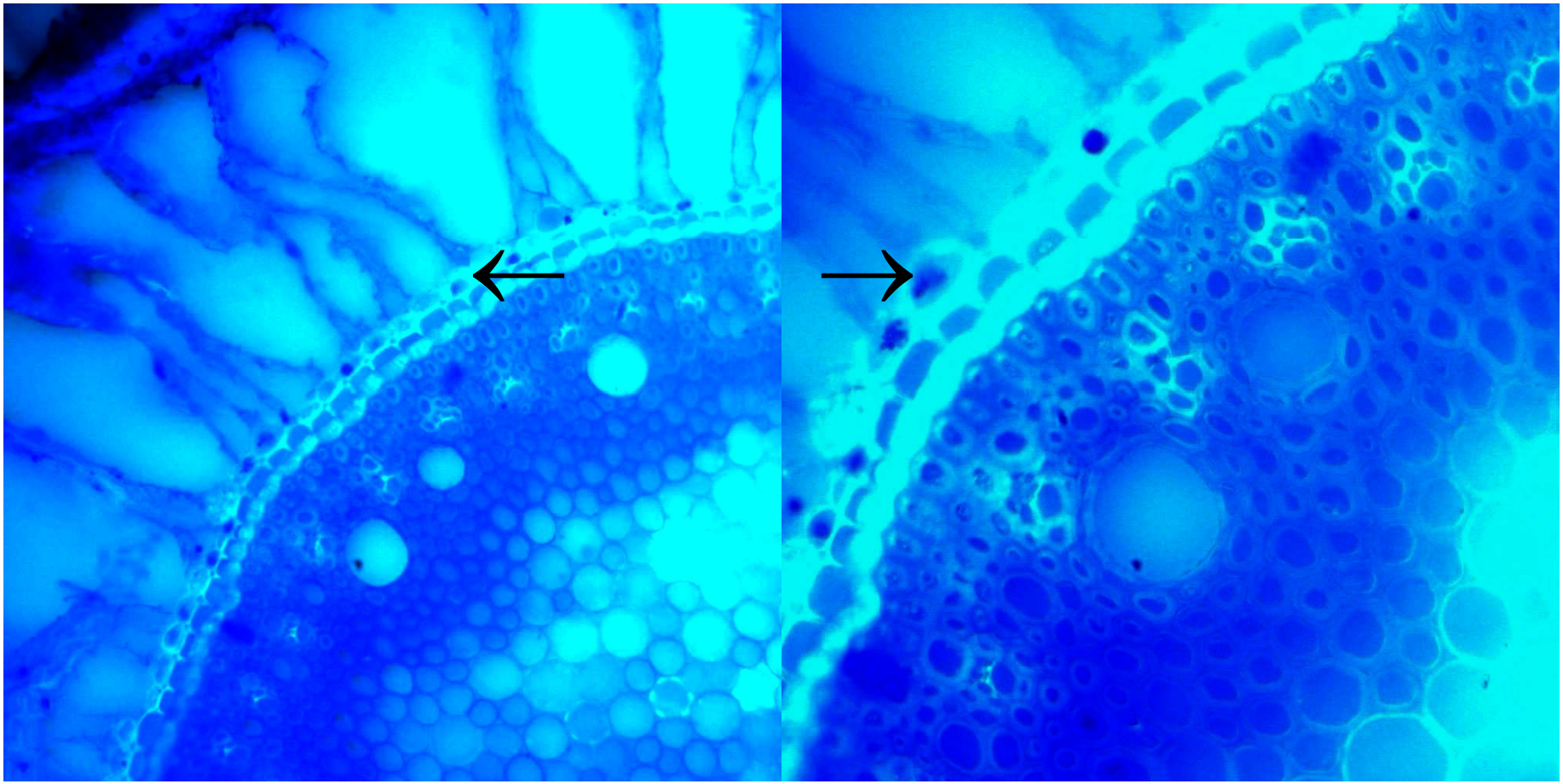


Root cross section showing essential oil secretary sites



Color pictures (A, B) by the author and b/w pictures (C) from Cinzia et al 2002 in *Vetiveria* (M Maffei ed.) Taylor and Francis

Fluorescent localization of oil secretary cells in bast region



Ideal root type for diverse applications

Essential Oil

Smooth – thick vertically growing roots with minimum branching, well developed phloem

Land / Slope Stabilization / Bioengineering

Profusely branching, spreading type with least essential oil

Water and Soil Reclamation

High absorption potential for soluble N, P and pesticidal residues

Detoxification and Pollution Mitigation

High absorption potential and tolerance to heavy metals

Management of Waterlogged areas

Spongy roots with schizogenous cortex

Carbon sequestration

Deep penetrating faster growing roots with low essential oil, thick vascular cylinder and suberised epiblema and endodermis

Approaches to Development of Application Specific Genotypes

- Scoring for vascular diversity to isolate smooth / branching types / tensile strength
- Hydroponic evaluation to facilitate identification for physiological tolerance and absorption potential
- Search for diversity for phloem / bast region can help identification of high / low oil producers

Evolution of root architecture during domestication – lessons from barley

Figure 1. Evolution of barley (*Hordeum vulgare*) seminal roots during domestication and breeding (seedlings grown in gel observation chambers). **(a)** The wild progenitor has only a few seminal roots, which are highly geotropic. By contrast **(b)**, modern cultivars have several seedling roots, which explore larger areas of the soil. **(c)** Landraces (early cultivated lines) are intermediate.

Strategic objectives vis-à-vis eco-friendly utilization of vetiver

Realization of non-invasiveness in seed forming vetiver

Enhancement of biological potential in given genotype

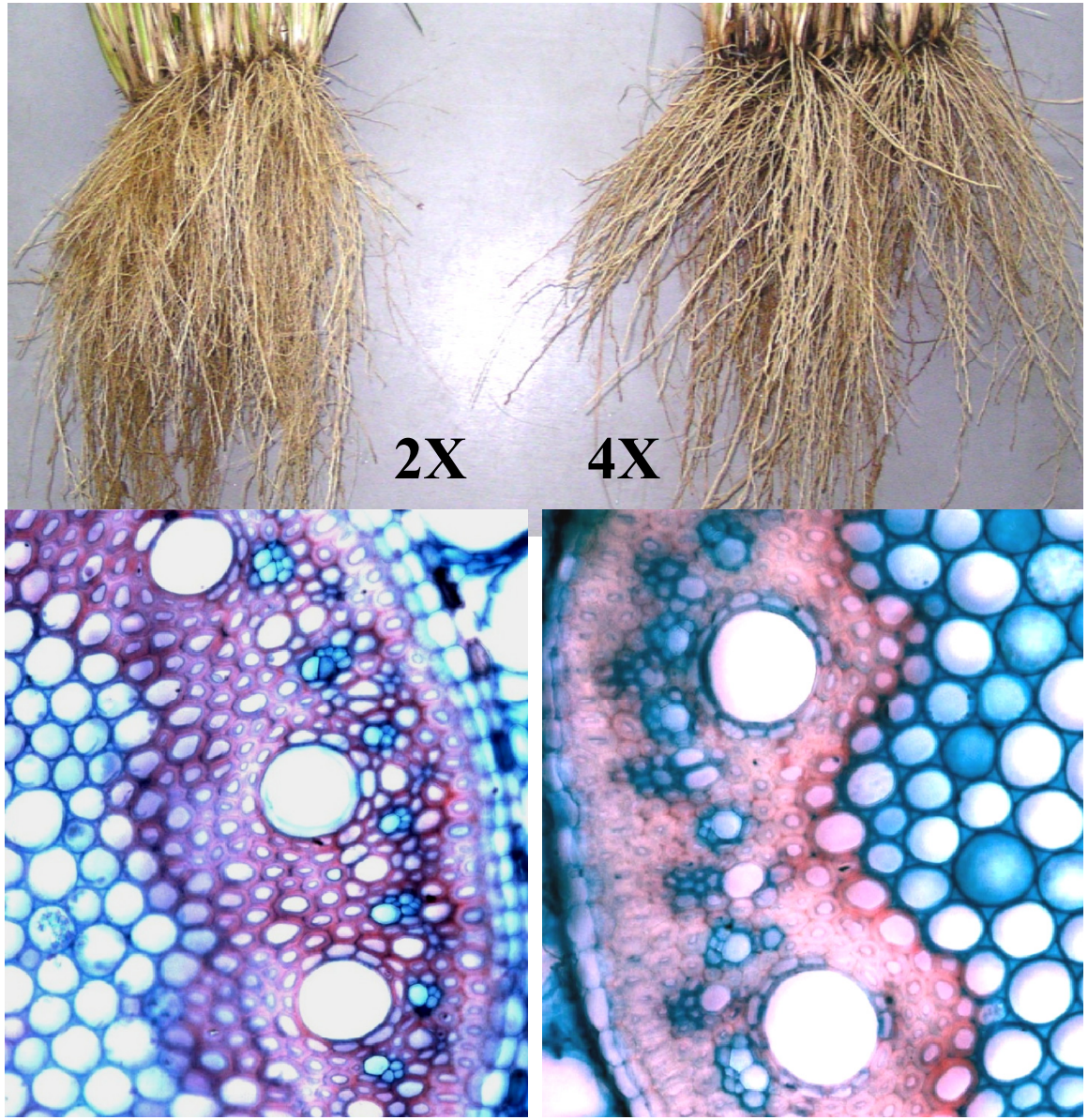
The above is being addressed by

Polyploid mediated realization of low seed / non-seediness features on account of disturbances in meiotic behaviour

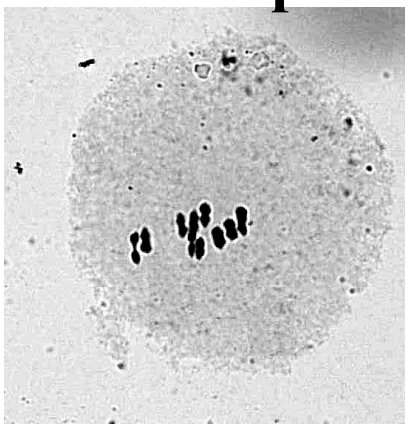
Enhanced metabolic potential on account of enhanced photosynthetic efficiency

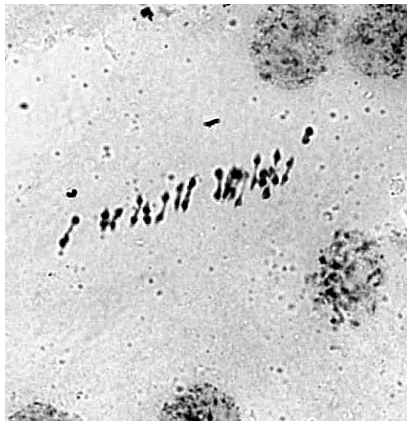
Increased cell size for enhanced essential oil and increased stellar region for enhanced tensile strength.

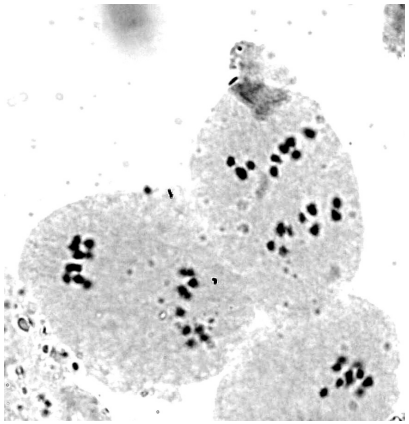
Polyploid mediated changes realized

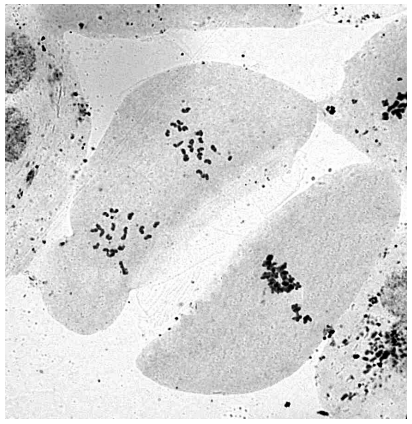


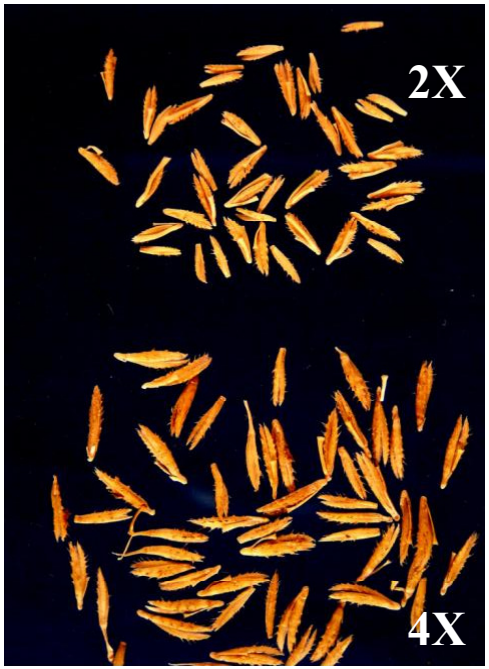
Cytological and reproductive features in diploid vs. tetraploid

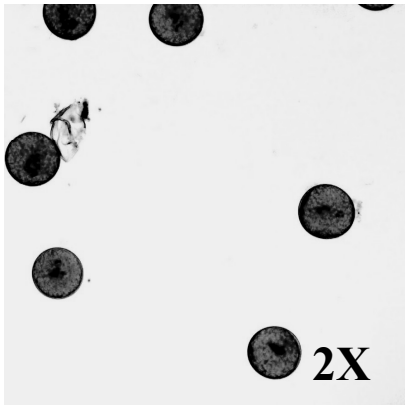


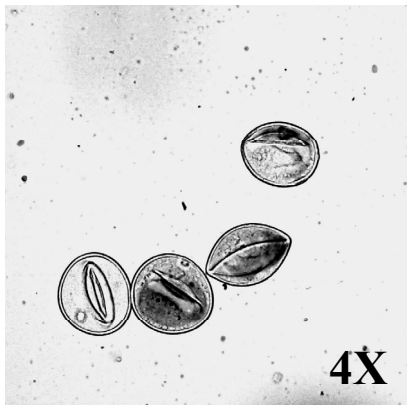












Morphogenetic Response to Ploidy Change

Riddle NC et al (2006) Theor Appl Genet 114:101-111