Vetiver Root System: Search for the Ideotype

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Abstract: Vetiver roots have a tufted vertically growing root structure. The roots are one of the most important organizational systems that make vetiver a miracle grass for its multifarious applications in soil and water conservation, soil health, and raw material for vetiver root handicrafts, environmental and perfumery products. A lot of diversity is found in vetiver root system in nature, and a search for root morphology and geometry could lead to a desired root type. Depending upon the requirement and specific situation it may be desirable to have a particular root type, and therefore search for root – ideotype.

For extraction of essential oil and root handicrafts, thick, smooth, long and vertically growing roots with high essential oil concentration are useful, but for conservation purposes horizontal anastomosising having secondary lateral roots with least essential oil could be preferable. For reclamation and detoxification of wetlands, and intercrop support on the slopes, vertical deep growing roots with high absorption potential may be desirable, and for bioengineering purposes a combination of the two i.e. long vertically growing laterally branching, with high tensile strength would be preferable. The issues involved are discussed vis-à-vis organizational composition of vetiver root system.
Key words: Vetiver root system, root ideotype, root diversity, root exo-morphology
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1 INTRODUCTION

Most of the important chemical and physical processes that influence biological world take place at interfaces. In the terrestrial life there could not be any thing of more functional importance than the interface between plant root and the soil they exploit, and the interactions with water, mineral elements and metals, and the micro-flora. Gravity-guided penetrative and branching property of roots that enables soil and rocky substrates to be explored and in a steadily expanding way that keeps in proportion to the aerial root system it supports, physically for stability and chemically for metabolic and reproductive ongoing, makes the root as the lifeline of plant machinery. Thus, in a true perspective roots are the most vital components strongly in contrast with their modest outward appearance just as physical support axes (Jackson, 2001). However, keeping in fitness with various plant forms and function, roots too have specific constitutional make-up, but variations in their micromorphological make-up do occur commensurate with genetic diversity. Latter may be explored from utilitarian viewpoint, and vetiver is a suitable case since its root system is an important organ having value for commercial and environmental applications.

2 THE VETIVER GRASS ROOT SYSTEM

Most grasses have fibrous roots, which spread out from the underground part of the culm and hold the soil in a horizontal pattern. The vetiver roots, however, penetrate vertically into the soil, whether it is the main root, secondary root or their fibrous ramification. In vetiver the roots are biologically the most important and economically the most useful part. In addition to absorbing water and maintaining soil moisture, vetiver roots help facilitate absorption of toxic substances, chemical fertilizers, pesticidal residues and heavy metals, improve physical elements and decomposition of organic matters. As such, their plantations are useful in soil and water conservation and maintenance of soil health (Anonymous, 1996). They serve as an important resource for extraction of aromatic essential oil used variously in perfumery and medicinal applications. Dry roots are used as the raw material for preparation of various household products and handicrafts (Lavania, 2003).

2.1 Structural Dynamics of Vetiver Root

Vetiver roots comprise of tufted mass originating from shoot base. In general, growth and behaviour of roots is coupled closely to the growth and behaviour of shoots (Davies and Jeffcoat, 1990). Mature vetiver roots, about 12 to 18 months old, evince well-developed vascular cylinder and persistent cortex. Whereas the bast region (extraxyllary secondary phloem) in root is the source of essential oil, the vascular cylinder (secondary xylem) provides physical and tensile strength to the vertically growing penetrating roots. Early secondary growth of roots with persisting cortex is the result of two different processes, the cambial and the dilation growth. During the secondary thickening of roots, dilation growth results in enlargement of peripheral layers appropriate to secondary thickening of vascular cylinder. Also, the development of lateral root primordia is the consequence of local changes in the rates and direction of cell growth. In grasses, primordial initiation of lateral roots occurs in meristems opposite to phloem, and is governed by resumption of division activity in the pericycle (Demchenko and Demchenko, 2001). Depending upon the physical condition of the soil, aeration, moisture and growth, dilation of cells could be appropriately adjusted having, compressed, dilated or aerencymatous sort of cells.

2.2 Growth Dynamics of Vetiver Root

In general the fibrous roots of grasses spread out from the underground part of the culm and hold the soil in horizontal pattern, but in vetiver they do not expand horizontally but penetrate vertically deep into the soil, be it the main roots, secondary roots or fibrous roots. Whereas, the initial growth of roots that spread in horizontal pattern is very fast making a mat of roots, but in vetiver the growth activity of the vertically growing roots is slow but steady throughout acquiring a total length of over 7 meters after a growth period of 36 months. Also, the vetiver roots show weak tendency to branch. As such, owing to vertical growth and weak tendency to branch the roots of vetiver grass rarely mix with the roots of other plants grown in vicinity (Tscherning *et al.*, 1995).

The rooting pattern of the other two *Vetiveria* species, *V. nigritana* and *V. nimoralis* show distinct differences with that of *V. zizanioides*. Whereas the roots of *V. zizanioides* are much longer and thicker than the other two, they also show much less secondary branching and little lateral fibrous roots.

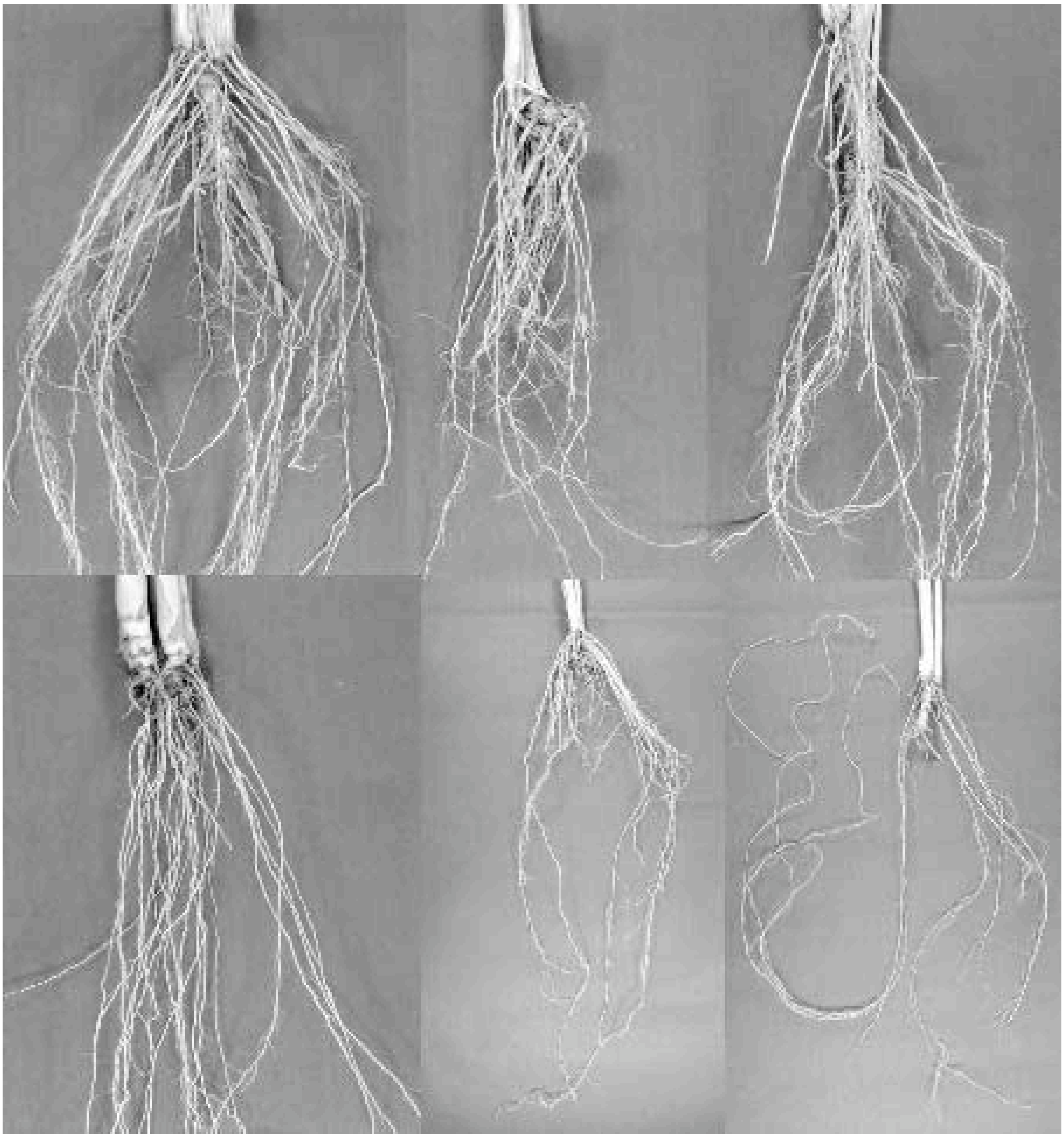
3.3 Vetiver Root Ideotype

Semi-technically 'ideotype' means 'ideal type' and with respect to plant this means 'ideal plant type'. Depending upon the requirement, the definition of a particular ideotype may suit specific needs. Since, vetiver root system has multifarious applications, therefore a root ideotype has to make best use of root characteristics both in terms of growth potential and qualitative features. It is, therefore, necessary to define the characteristic features of the root suiting to specific applications. In a broad sense utilization of vetiver root system could be categorized into three major categories: (i) vetiver roots for essential oil, (ii) vetiver roots for environmental applications, (iii) dry roots for handicrafts, and other household purposes.

3.3.1 Vetiver roots for essential oil

As mentioned above the essential oil is produced in the bast region, which is formed on account of secondary thickening. Obviously, it is mainly the primary thick root that is likely to produce higher concentration of essential oil of good quality. Secondary roots formed on such primary roots will have little bast region, and the tertiary fibrous roots virtually no bast region, and are therefore not likely to produce good quality and sufficient quantity of the essential oil. Also, it may be difficult to dig out the root-mass completely if the roots are too long (i.e. longer than 50 - 60 cm) on maturity suitable for oil extraction. Therefore, it is suggested that the root ideotype for root oil should have profuse rooting, thick and smooth vertically growing roots that can be easily dug out with minimum loss of root material.

Fig. 1 Showing representative morphotypic variations in vetiver root system (note root-thickness, spreading-habit, secondary rooting-pattern and root-length)



3.3.2 Vetiver roots for environmental applications

The various environmental applications of vetiver root include planting of vetiver hedgerows for soil and water conservation, detoxification of soil and water, and bioengineering uses. For soil binding in degraded soils it is desirable that soil surface is least disturbed / displaced. Accordingly a root form that binds to the root surface and covers more area with less plant population is desirable. Therefore, a root ideotype should have more fibrous horizontally spreading type forming anastomosis of root mass. Presence of secondary and tertiary fibrous roots would add value to such roots by increasing their soil binding potential, and also making them unattractive to root diggers due to least oil in such roots. For water conservation and detoxification of soil and water, high absorbing potential of roots is desirable. More spongy and fibrous roots providing large surface area, high tolerance to toxicity, deep growing roots are ideal for the purpose.

3.3.3 Vetiver roots for handicrafts and other household construction

Dried vetiver roots are extensively used for preparation of woven mats, curtains, etc. for providing cool air on dousing with water. Such woven root products are commonly hung to the ventilation sites and also used to prepare makeshift cool-cabins during summers. Thick spongy roots with rich concentration of essential oil with or without secondary roots may be ideal for such applications. However, for construction of compressed panels, fibrous roots with thick vascular cylinder may be desirable. The latter would not only provide strength to such compressed panel because of high tensile strength of thick vascular tissue but would also offer resistance to vibrations to the compressed panels. Plant genotypes resistant to grow in marshy and waterlogged conditions may offer suitable root types for such purposes.

4 DISCUSSION

Tremendous diversity for root form and above ground plant morphology and reproductive characteristics is known to occur in vetiver throughout the tropics. Vast range in essential oil concentration and quality, smooth to fibrous root system, as well as, tolerance to various kinds of soil constraints and toxicity are reported for vetiver (Chomchalow and Barang, 2002, Lal and Sharma, 2002, Lavania, 2002, Lavania, 2003, Lavania and Lavania, 2000,). Representative vetiver rooting patterns depicting variation in root exo- morphology are shown in the Figure 1. As such, it may not be difficult to isolate the desired root ideotype meeting the specific requirement. Also, there are two distinct categories of applications vetiver:

- For oil production, roots needs to be dug out from the soil, but for environmental applications they are left undisturbed on site. Because, digging out of roots is labor intensive, therefore vetiver root for oil should have sufficient concentration of essential oil to appear economically attractive;
- Whereas for environmental application, the root types should have least essential oil so that they remain unattractive to unscrupulous root diggers.

The root ideotypes outlined above meet such economic requirements. Although, final selection for desired root type would come only from the actual evaluation of roots itself, but for the initial screening for morphological appearance and the plant growth pattern above ground may be helpful, as there are strong correlations in morphological manifestations between root and stem growth.

Further, to make vetiver plantations really environment friendly, it is of utmost importance that they do not reach to undesired destination on account of their profuse seed dispersal. It is important that selection for root ideotype is either confined to non-seeding types, or the seed forming types are converted into non-seeding ones through triploid breeding (Lavania & Kumar 1998)

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A Brief Introduction to the Author

Dr. (Mrs.) Seshu Lavania is a Reader (Associate Professor) in the Department of Botany, Lucknow University, Lucknow, India. In addition to teaching to graduate students of Botany, she continues with her research work on plant morphology and floristics. She has published over 20 research papers, and has been actively associated with ecology and taxonomy of vetiver, and has published an exhaustive account on “Descriptors for vetiver”.