Editorial 1

Plant Architecture Determines the Productivity Potential of a Crop

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With an ever increasing human population and gravity of both biotic and abiotic stress, there is a great necessity to breed crop cultivar for adaptation under these stress situations as well as with good high yield potentials to ensure global food security. The prevailing situation of food grain shortage accompanied by abrupt price hike has alarmed the crop scientists and physiologists to identify comprehensive and convincing multidisciplinary approach to come up with the sustainable technology that must be validated on *in situ* farm level conditions. To meet this challenge, breeders in collaboration with other scientists are working hard to breed high yielding crop cultivars with significant progress. They have established selection criteria for genetic improvement of crops for yield and stress resistance. However, still there is a great necessity to identify simple selection criteria to make their process much easier (Maiti, 2008).

Commercial cultivars result from long and intensive breeding efforts to improve multiple traits including resistance to diseases, fruit or grain characteristics and plant development, which determine adaptation to agro-climatic as well as market conditions (Barchi et al., 2009).

The yield potential is defined as the yield of a variety when grown in fluctuating and adverse situations against biotic and abiotic stresses effectively controlled. Stress factors such as drought and salinity offer a great challenge to the breeders to breed crop cultivars tolerant to the gravity of these stress factors as alternative to assure food security. The identification of ideotype for a particular crop could be of great advantage to the plant breeders.

In order to facilitate the breeders' selection criteria, different scientists have put forward plant ideotype concepts on different crop species. The concept of ideotype was first proposed by Donald in 1968. According to Donald, the ideal ideotype of wheat should have the following characters: 1) short stature and short internodes; 2) leaves medium/narrow; and 3) stiff oriented at acute angle to the stem for efficient interception of light for photosynthesis and long panicle and large number of grains. The concepts of building this ideotype model is based on the morphological and reproductive traits associated with efficient capture of sunlight for photosynthesis and translocation of the photosynthates in the grains/products.

Rice is one of the most important cereal crops and is also a model plant for molecular biological research. The genetic modification of plant architecture and variety improvement in rice was reviewed by Yang and Hwa (2008). They suggest that the structure of the aerial part of a plant, referred to as plant architecture, is subject to strict genetic control, and grain production in cereal crops is governed by an array of agronomic traits. Recently, significant progress has been made in isolating and collecting rice mutants that exhibit altered plant architecture. In this report, the authors summarize the recent progress in understanding the basic patterning mechanisms involved in the regulation of tillering (branching) pattern, stem structure and leaf arrangement in rice plants. The relationship between the genetic modification of plant architecture and the improvement of pivotal agronomic traits in rice are discussed.

Similarly, different authors proposed the ideotype of dwarf rice; most productive tillers; short stem height; higher culm diameter; slow internode elongation; short erect leaves having medium width; higher number of panicles m^{-2}; high harvest index. IRRI, Philippines proposed for direct seeded rice having 3-4 tillers $plant^{-1}$; 200-250 grains $panicle^{-1}$, while under rain-fed condition, it should have 6-10 tillers $plant^{-1}$; 150-200 grains $panicle^{-1}$.

Development of the ideotype concept has focused the attention of plant physiologists on identification of simple morphological characters which have some influence on physiological processes determining the yield of the economic organs (Thurling, 1991). Characters such as leaf inclination and leaf shape, for example, are often simply inherited and can greatly influence crop canopy structure and radiation interception. Such characters could be rapidly modified by selection to increase crop photosynthesis and yield. Ideotype definitions integrate information on these relationships and provide plant breeders with a clear blueprint of the characteristics of a high-yielding cultivar in a specified environment (Thurling, 1991).

Plant breeders have attempted to enhance yield by selecting for individual traits since the beginning of plant breeding. This approach has been broadened to encompass the breeding of model plants or ideotypes. An ideotype is a hypothetical plant described in terms of traits that are thought to enhance genetic yield potential. Ideotype breeding is defined as a method of breeding to enhance genetic yield potential based on modifying individual traits where the breeding goal (phenotype) for each trait is specified. Successes that have occurred in breeding to enhance yield with individual traits, the value of genetic diversity for individual traits, and benefits from goal setting are presented as arguments in support of ideotype breeding. Alternatively, information is presented on the requirement of symmetry in size among plant parts, compensation among plant parts, pleiotropy, and genetic background, all factors that may slow progress in ideotype breeding. Ideotype breeding is recommended as a methodology to augment traditional plant breeding, when the breeding goal is enhancing genetic yield potential. Breeding experience and research to date suggest that ideotype breeding is not a suitable substitute for traditional yield breeding (Rasmusson, 1987). Maiti (2008) proposed conceptual ideotype concepts of few crops (figures 1). In cotton, the ideal ideotype under high input situation should be open leaf canopy, long stout and strong petiole for efficient interception of light energy; stout strong stem, intermediate internode length, big

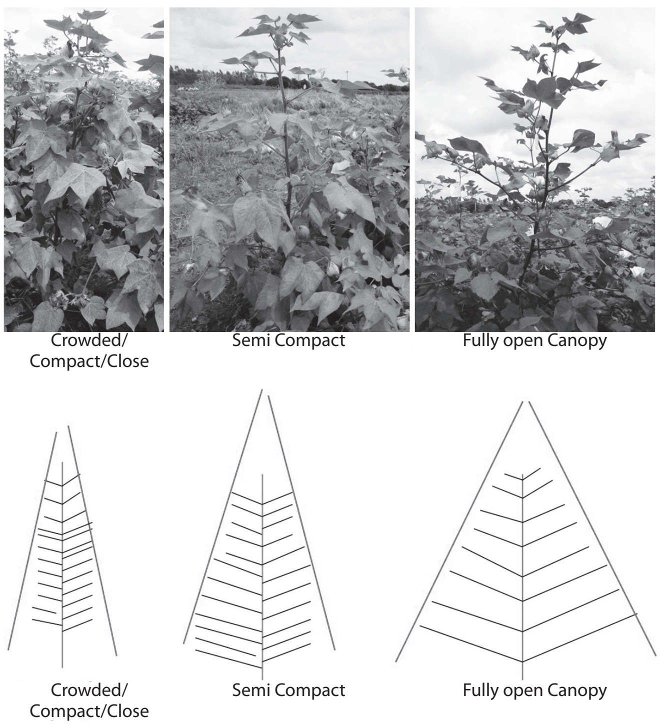


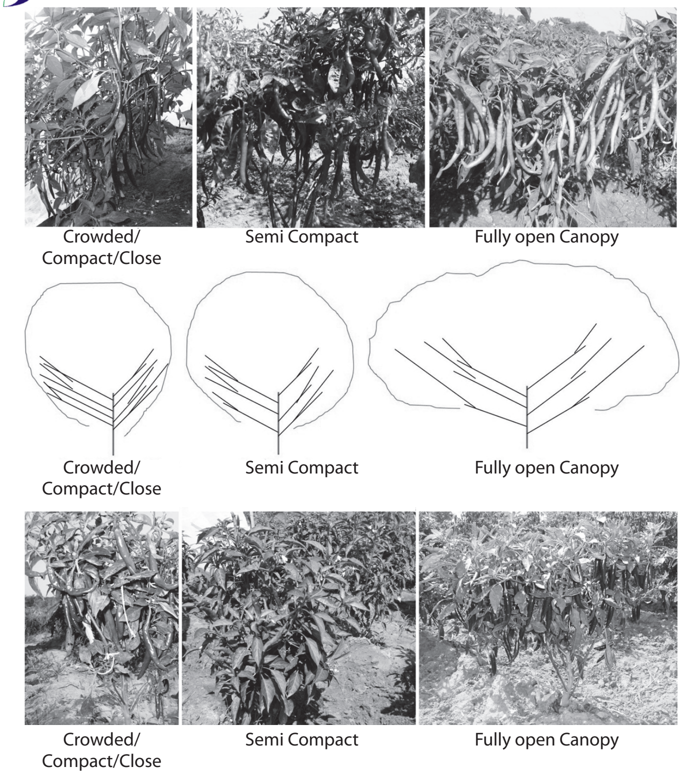
Figure 1: Ideotypes and architecture in cotton

boll size, high boll number, sympodial branches of medium length to accommodate more plants between rows and strong deep rooted.

Maiti (2008) proposed two plant types in chilli, viz. determinate (short and early maturing) and intermediate (tall and medium maturity) (Figure 2). The growth habit is intermediate or erect or rarely tall types. Later it is assessed that open canopy in the form of umbrella produce higher number of long chillis hang from below indicating direct ranslocation of the photosynthates in the fruits. Chilli with crowded leaves produce though greater number but small sized fruits.

Similar ideotype concepts have been proposed for tomato shown in figures. Plants with crowded leaves produce small fruits due to competition for light, nutrients and water.

On the basis of these concepts, it is hypothesized that plant



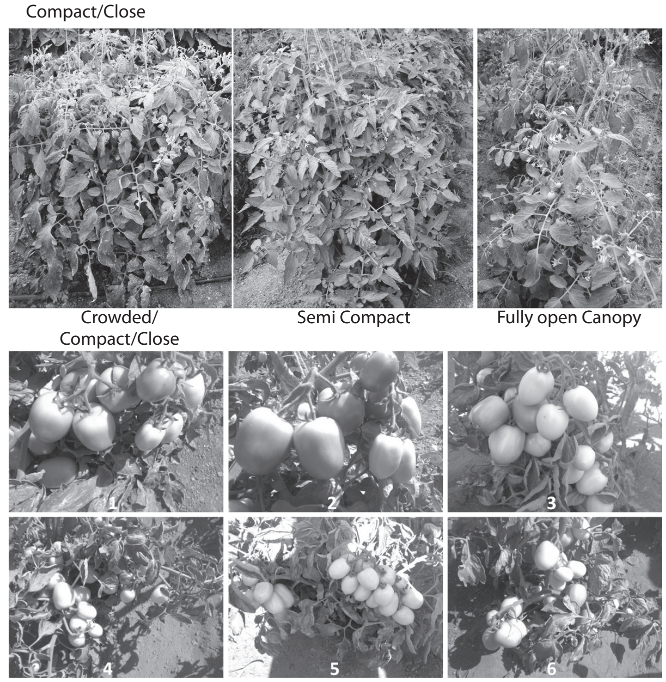


Figure 3: Ideotypes and Architecture in Tomato

architecture determines the productive potential of a crop species which may be justified later. Plants with crowded leaves indicate wastage of resources, light energy, water and nutrients especially under drought situations. This concept may be open to criticism or does not hold good in special cases.

Higher plants display a variety of architectures that are defined by the degree of branching, internodal elongation, and shoot determinancy (Wang and Li, 2008). Studies on the model plants of *Arabidopsis thaliana* and tomato and on crop plants such as rice and maize have greatly strengthened the understanding on the molecular genetic bases of plant architecture, one of the hottest areas in plant developmental biology. The identification of mutants that are defective in plant architecture and characterization of the corresponding and related genes will eventually enable to elucidate the molecular mechanisms underlying plant architecture. The achievements made so far in studying plant architecture have already allowed optimizing the plant architecture of crops by molecular design and improving grain productivity.

The architecture of a plant depends on the nature and relative arrangement of each of its parts; it is, at any given time, the expression of an equilibrium between endogenous growth processes and exogenous constraints exerted by the environment. The aim of architectural analysis is, by means of observation and sometimes experimentation, to identify and understand these endogenous processes and to separate them from the plasticity of their expression resulting from external influences (Barthélémy and Caraglio, 2007).

The endogenous regulatory principles that control plant architecture were documented by Reinhardt and Kuhlemeier (2002). These authors propose that plant architecture is species specific, indicating that it is under strict genetic control, although it is also influenced by environmental conditions such as light, temperature, humidity and nutrient status. In addition, the basis of leaf architecture and the role of cell division and cell growth in morphogenesis influence plant architecture.

High-resolution Quantitative Trait Locus (QTL) mapping methods are being developed that may define the specific DNA sequence variants underlying QTL. Studies of genetic architecture, combined with improved knowledge of the structure of plant population, will impact the understanding of plant evolution and the design of crop improvement strategies to enhance plant growth, development and productivity (Holland, 2007).

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