Preface

Dormancy is a mechanism found in several plant species developed through evolution, which allows plants to survive in adverse conditions and ensure their perpetuation. This mechanism, however, can represent a barrier that can compromise the development of the species of interest, and therefore, the success of its cultivation. It is important to understand the causes, effects, and mechanisms, as well as the technologies for overcoming dormancy of buds, seeds, and plant propagules. In this context, this publication has as a main objective of offering an in-depth view of the dormancy process in cultivated plants, based on a survey of more recent international research on the subject.

Written by several researchers from different institutions of education and research, this book presents information on the most diverse species of plants of agronomic and forestry interest. In addition to the physiological, biochemical, and genetic aspects, the chapters also address the possible causes of dormancy, as well as technological issues that are essential for the successful cultivation of several economically important species.

The focus of this publication is on temperate fruit species. Classical examples of temperate plants that present dormancy are fruit trees such as apple, pear, quince, apricot, and cherry. These pome and stone fruits are typical representatives of a deciduous temperate climate, wherein trees drop their leaves at the end of the reproductive cycle, consequently entering dormancy.

Dormancy has its control effected by factors of a hormonal nature, where the hormone promoters and growth inhibitors are balanced. Edaphoclimatic conditions also affect plant dormancy periods, for the most part through temperature changes. Other chapters in this book are dedicated especially to potatoes, vegetables, as well as forest and forage species, which makes this text a complete and comprehensive work on the subject.

Chapter 1 - Dormancy is a multiple and complex phenomenon which multiplicity stems from the fact that it affects several plant structures. Surviving an unfavourable season - such as the winter time of the year, mainly due to low temperatures and even a possible thick snow cover - implies in many manifestations that interfere in dormancy: formation of protection structures, accumulation of metabolites in specific tissues, mechanisms of resistance, among others. Classical examples of temperate plants that present dormancy are fruit species such as apple, pear, quince, apricot and cherry trees. These pome and stone fruits are typical representatives of deciduous temperate climate, which drop their leaves at the end of the reproductive cycle, consequently entering in dormancy. Dormancy has its control effected by factors of hormonal nature from a regulation where the hormones promoters and the growth inhibitors are balanced. Edaphoclimatic conditions, for the most part by the temperature, also affect the plants marking the entrance and the exit of the dormancy period. Types or classes of dormancy as ecodormancy, endodormancy and paradormancy, may interact with each other chronologically, and when it happens, they therefore constitute phases within the total dormancy period, in addition to involving some common control mechanisms. The multiplicity of facts and phenomena that occur in the plant in the pre-dormancy period until its overcoming, subject to hormonal balances and imbalances, climatic and soil conditions, and added to anthropic intervention activities, such as cultural practices, are responsible for a new life cycle - growth and reproduction - of deciduous plants of temperate climate.

Chapter 2 - The use of methods to estimate chilling requirement of temperate fruit trees are important tools for the prediction of physiological phase changes in the plant, as well as the decision making on the cultural management to be carried out in the orchards. Several methods can be used to estimate chilling requirement of temperate fruit trees. They can be basically divided into biological methods and temperature modeling methods. Biological methods are those characterized by direct phenological observation (sprouting and flowering) of plant material (parts of plants or whole plants) submitted to controlled and distinct conditions during dormancy. In general, this method is used in experiments to characterize genotypes with respect to the chilling requirement or for studies of temperature modeling, evaluating the behavior of the buds in different situations. On the other hand, the methods of temperature modeling have the objective of measuring the amount of chilling accumulation during the winter period and, from the characterization of the need of the different cultivars, it is possible to predict the time of budbreak. Although widely used and an important tool in the management of fruit trees, this second method presents a very variable performance in certain conditions and crops, since the methodologies developed, for the most part, were based on empirical observations and not on physiological processes. Advances in studies on the mechanisms involved in tree dormancy control contribute to the development of more accurate models, increasing efficiency in predicting the physiological development of trees and improving information for decision-making in orchards management.

Chapter 3 - Bud dormancy of temperate species is a natural and necessary cyclic process that occurs as part of a plant protection system against low temperatures during the winter. Several climatic factors are involved in this process, with emphasis on temperature, and internal factors such as phytohormones, carbohydrates, growth inhibitors, water content, enzymes and oxidative stress. Due to the interaction among these factors, the study of dormancy is complex and several methods have been developed to evaluate the presence and intensity of dormancy. In this chapter some of these methods will be described, discussing how they can be performed and their results. The Tabuenca's test is used for evaluation of floral buds dormancy. The single node cutting test is one of the most used to evaluate dormancy intensity. The dormancy index was created to more clearly characterize the dormancy intensity from the results of the single node cutting test. Biochemical tests can be performed to quantify various substances involved in the dormancy process, such as carbohydrates, enzymes and reactive oxygen species. The tetrazolium test is a newly developed test to rapidly quantify the respiratory activity of buds.

Chapter 4 - The best and most efficient way to avoid problems related to dormancy on deciduous fruit trees is the use of cultivars adapted to the amount of winter cold in the growing region. In addition to the use of cultivars with low chilling requirement, there are some technical interventions that can minimize the effects of lack of chilling on low sprouing and flowering, such as artificial chilling, ring incision, arching of branches, growth control, post-harvest pruning and defoliation. After the nursery trees are removed from the soil, they can be stored in a cold room for a period of 30 to 45 days at 2 to 6 °C, allowing a uniform sprouting and greater branches growth. The ringing can be used, in the first and second year, for the plant in formation of the upper layers when a suitable sprouting for the plant formation did not occur. In the climatic conditions of southern Brazil, the period of vegetative development of temperate fruit trees is superior to that observed in typical regions of temperate climate, which associated with high temperatures and high rainfall rates during the cycle can result in excessive branch growth. Under such conditions, the use of management techniques that restrict vegetative development becomes essential. Among the measures to control the vegetative growth of the branches of the year, the use of calcium prohexadione is efficient in apple, pear and plum tree crops. In mild climatic conditions the temperate fruit trees resume the vegetative growth after harvesting, under these conditions pruning when the plants still have leaves reduces the plant vigor and photoassimilates are reallocated to the reproductive organs that will remain in the plant. Arching provides a weakening of the branches, favoring sprouting. Branches ringed to interrupt the normal circulation of sap also favor sprouting. In regions of subtropical climate or in years that the temperatures are not too low in the autumn-winter, the natural fall of leaves does not occur. Under these conditions it is necessary to make chemical defoliation, which should preferably be carried out with chemicals that promote leaf senescence.

Chapter 5 - Hibernal dormancy of vines are characterized by a plant state of physiological inactivity, which allows its survival under adverse conditions. In this period, the plant does not show vegetative growth, but its metabolic activities continues, although reduced. For these vines to resume the growth naturally, its exposure to a certain period of low temperatures is required, called chilling units. The dormancy presents progressive development that begins during the autumn, increasing its intensity until reaching the deep dormancy or endodormancy, conferring the capacity of survival in temperatures unsuitable to vegetal development. Thus, one of the major limitations for grapevine cultivation in tropical and subtropical regions, where the amount of hibernal chilling is not enough, is the overcoming of your period of dormancy. In these regions, the application of some substances is a strategy that can be used to induce bud burst, flowering and ripening of temperate climate fruit species like vine. Among several substances that have an effect on artificial induction of bud burst, the authors highlight the hydrogen cyanamide, successfully used in several vine growing regions, as well as other promising products such as mineral and vegetable oils and garlic extract. This chapter approaches the main aspects related to grapevine dormancy, as well as the strategies for induction of a new cycle in tropical and subtropical regions through application of bud burst inducers.

Chapter 6 - In a world with increasing population, food production to feed this population growth is crucial. Potato ranks third as the main source of food in the world. In potato's production in the field, the use of tuber seed with appropriated sprout growth is important to achieve high yields. The start of the sprout growth of potato tubers, in turn, is dependent on the breaking of dormancy. In addition, after tuber harvest, it is important to maintain tuber dormancy in order to keep the quality of this tuber. In this chapter, the authors stated the definition of potato tuber dormancy, showed the influence of dormancy on tuber yield, gave the main managements to keep or break tuber dormancy and reported on the factors affecting dormancy period. In the sequence the authors discuss the physiological aspects of tuber dormancy, i.e., the main plant hormones that are related to the regulation of this process. Finally, the authors present the genetics of tuber dormancy and release, presenting the newest findings in this area of study and the future steps to achieve a better understanding of the genetic control of the breaking of dormancy in potato tuber. The authors hope that this text would help technicians and growers to better understand and manage this important food crop.

Chapter 7 - Of the US $ 4.6 billion in world trade of vegetable seeds, Europe and Asia account for 70%. Of this amount, Brazil is responsible for moving about US $ 100 million. Considered by several experts as an excellent business environment in the world context of the seed industry, Brazil manages to combine its agricultural vocation with a good technological system. Furthermore, the Country has a continental characteristic, providing suitable climatic conditions for the production of high quality seeds of tropical and temperate species. Among the difficulties encountered in the seed production sector, dormancy stands out, which is usually an undesirable characteristic in the olericulture, since the rapid germination and growth are required as a primordial factor. The knowledge of dormancy mechanisms and their duration in the different vegetable seeds are ecologically and economically important, since they help in the selection of specific treatments that act on the metabolism of the seed, releasing the embryo for development or making it apt to germinate. Dormancy allows distribution of germination time, and is also an adaptive feature that ensures the survival and perpetuation of the species in the different ecosystems. The germinative delay maintains the species at the seed stage, i.e., at the stage of the plant cycle in which its resistance to the unfavorable conditions is greater. Seed dormancy is controlled by the genotype associated with: environmental factors, such as temperature; physical factors, such as tegument thickness; and regulation of hormones such as abscisic acid and gibberellin. Generally, plants produce seeds with various levels of dormancy. This aspect helps to distribute their descendants through time and space. In addition, it allows the seeds not to germinate during the adverse periods, guaranteeing a time required for the dispersion to the greater geographic distance, providing the survival of the species. In order to standardize and potentiate the germination of some seeds, it is necessary to identify the type of dormancy. Thus, this chapter presents several specific methods for breaking dormancy in vegetable seeds, considering mainly aspects of physiological and morpho-anatomic of the seeds.

Chapter 8 - The Mixed Ombrophilous Forest (MOF), also known as Araucaria Forest, is a phytophysiognomy located within the Atlantic Forest, the fourth most important biodiversity hotspot on the planet. Due to the great diversity of species present in this phytophysiognomy, it is important to know its ecological characteristics, as is the case of seed dormancy. In the MOF, most of the seeds are classified as orthodox, present physical dormancy, low to moderate germination. Several techniques are used to overcome dormancy of forest seeds. The procedure is performed to accelerate germination process, among techniques, chemical and mechanical scarification are the most applied in seeds of the MOF species, due to high percentage of seeds with physical dormancy. It is verified that the majority of species that present dormancy belongs to the families Fabaceae and Lauraceae, mainly the species of the genus *Ocotea*, that are present in the forest upper stratum. In addition, some seeds require pre-germination treatment, even if they do not present dormancy. Therefore, the information on seed dormancy of the species of the MOF generating an important tool for better decision making in management of forest recovery techniques.

Chapter 9 - In forage legumes, seeds with physical dormancy (hard seeds) are not exceptional and during the germination test their embryos do not imbibe or germinate due to a physical impediment of their seed coats. This paper presents aspects related to physical dormancy studied in alfalfa (*Medicago sativa* L.) and white clover (*Trifolium repens* L.), and the results are compared, showing similarities and differences between the samples of both species. The studies carried out in alfalfa seeds of cv. Baralfa 85 and white clover seeds of cv. NK Churrinche (2004 and 2006 harvests) analyzed the following aspects: weight and moisture content, passage of water to the embryo, viability, anatomical characteristics, determinations of structural substances, polyphenols, tannins, cutin and ions present in the testa of seeds with and without physical dormancy. The comparative analysis indicates that both species have physical dormancy with different levels of depth, which is overcome over time. The amount of seeds that break dormancy during the period when they are immersed in water is different between species. Physical dormancy is related to seed moisture content and modifications that occur in the seed coat, which differ between seeds without dormancy and hard seeds. The different degrees of depth of physical dormancy and the differences between species can be explained in terms of the characteristics of the testa: thicker cuticle and longer macrosclereids, thicker cell wall, and more conspicuous osteosclereids and in higher numbers, as well as accumulation of lignins, tannins, polyphenols and pectic substances, and the amount of cellulose and hemicellulose. The ions found can be related to the components of the cell wall in which they are found and the cementing properties of these substances. Physical dormancy is a mechanism that protects the embryo and, together with the low moisture content found in hard seeds, ensures longevity, prevents deterioration and predisposes most of the embryos to develop into normal seedlings. These characteristics of the seed coat prevent dehydration of the embryo and slow down exchanges with relative humidity of the environment, favoring good seed storage. A fraction of white clover seeds presented deeper dormancy than in alfalfa.

Chapter 10 - Dormancy is a resistance or adaptive mechanism that plants have developed as a way of surviving adversities during the winter period. Dormancy is not a rapidly acquired mechanism, but a progressive development process that begins during the fall, increasing in intensity until reaching the so-called deep dormancy or endodormancy during the winter. This phase can be induced by internal and external factors and is regulated by their interactions: environmental factors, such as photoperiod and temperature; and by physiological factors that include phytohormones and biochemicals (sugar, starch and carbohydrate content). The intensity and the way this phenomenon manifests in temperate plants, different growing environments, has an important impact on the control, maintenance and production of such species. Thus, a better understanding of the types of dormancy (paradormancy, endodormancy and ecodormancy) and the characterization of the growing environment are important to obtain satisfactory yields and to determine the most suitable agronomic techniques. This chapter presents to the reader the internal and external aspects related to the induction and exit of dormancy, as well as methods of evaluating the stage of dormancy.