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ALTERNATE BEARING AND MACROCLIMATIC RELATIONSHIPS

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ABSTRACT

The potential for alternate bearing associated problems in pecan is greatly enhanced when trees are stressed. Weather related events, as influenced by climatic factors, are major regulators of alternate bearing in commercial orchards. Climatic characteristics are regulated by macroclimatic factors which have the potential to drastically and radically alter climate and associated weather. Some of these major macroclimatic factors are introduced and briefly discussed regarding their contemporary characteristics. A question is raised pertaining to the vulnerability of the U.S. pecan industry as related to weather related factors. A brief discussion is presented pertaining to how growers, etc. can act to buffer themselves against the economic impact of greater than normal environmental stresses.

INTRODUCTION

An objective of this workshop is to bring to everyones attention information or ideas that can potentially impact on our ability to understand pecan and its entire cropping system, from planting to retailing, so we can aid growers and others associated with the crop to efficiently maximize profits and to provide a quality product to American consumers at a fair price. It is my intent in this communication to present some information about the world in which we live and how certain events could possibly produce a major and dramatic impact on the U.S. pecan industry and its future and on our individual strategies for addressing our goals as mentioned above.

As a long-lived perennial crop, many decisions made today regarding our pecan husbandry strategies will have long-lived ramifications that may not be readily apparent; many of which may not be economically correctable, or if so, then only after considerable economic pain. This long-lived nature subjects pecan growers, and other industry affiliates, to much greater potential vulnerability than those who husband most other crops, especially annual or biennial crops. What facilitates an acceptable level of revenue today may be miserably deficient tomorrow. As key individuals influencing decisions made by the industry and its affiliates we scientists need to not only address current problems but also function as a watchman who scans the horizon for the approach of unexpected problems, especially being on lookout for those of potentially great destructive influence. When we think we see an approaching problem on the horizon we are faced with a decision as to whether we should sound the alarm or just to continue as if all is well but keeping an eye on what may possibly be happening on the horizon. There are potentially great risk associated with either option and this risk is proportional to just how big the perceived or real problem, or approaching storm, might be.

From my perspective, I think I see several such storm clouds on the horizon, a virtual squaw line of dark clouds. Among these are: greatly reduced funding for real-world research on pecan; increasing inability of the industry to effectively function as one entity focused on the common good; loss of most of the more useful chemical weapons currently relied upon to defend against disease, insect, and weed pests; and decline in pecans portion of the share of the market that which is presently possessed by tree-nuts. There is however one storm cloud that appears to be developing on the horizon that could potentially dwarf all others, as does the giant cumulonimbus (which spawns tornadoes) towers over the typical summer afternoon cumulus. This cloud, or potential problem, is that we may possibly be on the threshold of entering an era of greatly increased atmospheric instability or flux; or stated another way, a substantial change in weather characteristics, or perhaps even a change in our climate. While proof for such a short-term change remains elusive, climatologist know that in regards to climate, nothing stays the same. All will change, its just a question of how much and when. They have accumulated data that many of them interpreted to indicate that a short-term change may be much sooner than anyone had previously thought. What does this mean to the U.S. pecan industry? Should pecan growers begin to consider countermeasures so they can be buffered as much as possible against such an event? Should we wait for more information? What can the pecan industry or its individual components do?

The objective of this communication is to point out a possible concern, provide orientation regarding some of the macroclimatic factors which control atmospheric conditions, present some evidence that raiseds ones suspicions that something might already be happening, and to suggests in a general manner some precautions that might be considered by orchard managers/growers if such events transpire. The theme of this discussion is therefore "weather and climate" and whether the pecan industry is exposed to greater risk than it realizes.

BACKGROUND

At the level of the pecan tree, alternate bearing is regulated by physiological processes which are directed by the interaction of environmental and genetic factors. The interaction determines the period and amplitude of the alternate bearing mode. Modes are potentially present at

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several levels, these being: major limb, tree, orchard, and geographical. While alternation patterns for individual trees are typically biennial, patterns are also present within states and at the national level . For example, production cycles in the U.S. as a whole exists with periods of 2 years for cultivar nuts and both 2 and 9 years for seedling nuts. Production in Georgia cycles on 3 (Cultivar) and 13 (Seedling) year cycles, whereas that in Texas is on a 5 and 9 year cycle for cultivars and a 2 and 9 year cycle for seedlings. Such cycles and epicycles can arguably be attributable to a variety of factors however extreme weather events are likely the salient candidate because of their profound influence on major stress factors such as water, temperature, sunlight, and pests.

Pecan growers, and the trees they husband, are essentially "bottom dwellers" in an rather shallow ocean of gases and are therefore subject to the direct and indirect influences of this ocean on fundamental environmental properties such as the timing and magnitude of temperature, light, precipitation, and wind. Such factors, of course, act and interact to bless or curse the fortunes of this oceans inhabitants. Its circulation patterns are fortunately rather stable and largely predictable over a period of a few days but somewhat unpredictable over months or years; although, the general characteristics of the annual cycles are presently highly predictable. This long-term predictability has obviously allowed us "bottom dwellers" to confidently establish our orchards in geographical locals where the trees we husband are satisfactorily adapted to the physical characteristics of that particular locations gaseous environment. Under such conditions, nut yields and revenues are secured and we prosper if were smart and/or lucky. Prosperity is not just dependent upon wise judgement in the selection and execution of cultural and management strategies but also on atmospheric stability. Increased instability in this gaseous system can easily increase the stresses to which our trees are exposed and disrupt revenues via alternate bearing and a multitude of other means.

MACROCLIMATIC FORCES

There are several macroclimatic forces that control atmospheric stability. Five of these are briefly discussed as follows:

Solar irradiation. Energy received from our sun is the primary driving force of our climate and weather. Relatively small changes in the receipt and retention of solar irradiation can produce major changes in atmospheric characteristics. Due to the spherical nature of our planet intercepted sunlight results in the tropical or more equatorial portions receiving more energy than that of extratropical regions. This imbalance and subsequent energy gradient drives atmospheric and oceanic movement. There is also unequal heating within tropical regions. Heating is greatest where atmospheric convection is greatest. These are in the Amazon Basin, equatorial Africa, and Indonesian archipelago. These three regions of extra strong heating are terrestrial fire-boxes that energize circulation of both atmosphere and oceans. Any factor which influences either tropical or extratropical heating therefore influences circulation which in turn alters weather and potentially climate.

Of potentially several candidates, two in particular are thought to exhibit an inordinate threat to the atmospheric systems stability. These are the suns stability and the disappearance of forest within these "fire-boxes". Peculiar oscillations have recently been observed in the sun. This is a concern since the fusion processes bathing earth with radiant energy is in a state of flux . The dynamics of this fusion process causes increases in magnetic storms on the sun and subsequently appears to influence earths temperature and subsequently weather. These storms or spots have a mean period of 11 years but can vary greatly. Similarly, deforestation within the local fire-boxes threatens to alter the transfer of energy within the atmosphere and therefore will influence weather.

Polar Jet Stream. The atmospheric hemispheres are encircled by a narrow current of fast moving air which meanders around the globe, oscillating from North to South. This current, or river, is about 300 miles wide and nearly two miles deep. Wind speeds typically vary between 100 and 300 miles per hour. It exercises two key roles. First, it guides low pressure systems, or storms, around the hemispheres; therefore, exercising major control over when and how storms will occur and tract. Second, it serves as a boundary between warm and cool air, thus controlling surface temperatures and the formation of storm systems.

Bermuda High. This is a large mass of warm moist tropical air which moves westward from the Caribbean to the western Gulf of Mexico and then to the eastern half of the U.S. It oscillates from North to South and a primary regulator of weather in the eastern U.S.
The Bermuda High and the Polar Jet are usually far apart. When they get close together a lot of rain is produced along the ascending portion of the Polar Jet and dry weather in produced to the southeast of this zone.

Greenhouse Gases and Dust. Entry of certain gases, such as carbon dioxide, sulfur dioxide, methane, etc. into the atmosphere interfere with the escape of radiation from the earths surface, creating a Greenhouse Effect in which less energy is lost and the atmosphere is heated. Industrialization has contributed substantial levels of such gases to the atmosphere and therefore potentially affects weather. Volcanism is also a major source of such gases and it also contributed great amounts of dust to the atmosphere which increases reflectance and thus alters the energy balance of the atmosphere.

Southern Oscillation/El Nino. The Southern Oscillation is a standing wave, "see-saw", in atmospheric mass involving exchanges of air between Eastern and Western Hemispheres with centers of action over Indonesia and tropical South Pacific Ocean. When air pressure is great in one area it is proportionally less in the other. This standing wave influences atmospheric circulation patterns. One process by which it does so is via 'teleconnections'. An alteration in the characteristics of an atmospheric wave in on portion of the wave train results in alterations downstream. For example, oscillations in the Southern Oscillation can influence the Polar Jets which in turn influence storm systems and the latitudinal movement of air masses thus local weather characteristics are influenced. This principle of teleconnection provides a linkages over great distances of seemingly disconnected weather anomalies. Other "Oscillations", such as the "North Pacific Oscillation" and the "North Atlantic Oscillation" are therefore linked to each other by "teleconnections" and the "Southern Oscillation" is thought to be the most powerful anomaly of the any of the various "Oscillations". The Southern Oscillation is intimately associated with certain cold/warm water currents in the eastern Pacific Ocean. Strong oscillations in this anomaly result in the formation of Pacific Ocean currents which also alter weather systems. These two phases are termed "La Nina" and "El Nino". Weather events on many portions of the globe exhibit close associations with these "El Nino-Southern Oscillation" phases. This phase results in an invasion of warm water from the western equatorial Pacific into the eastern equatorial Pacific Ocean resulting in a warming of the tropical Pacific region. This can results in abnormally wet weather in the southern U. S. pecan belt, flooding in the South, with severe storms in the southwest. Similar weather is experienced in western Ecuador and Peru and the United Kingdom. Excessively dry weather i s experienced in equatorial Africa, eastern Brazil, northern China, eastern Australia, and Indonesian archipelago. Also, warm winters are encountered in the northern U.S. and western Europe with exceptionally cold in Siberia and Greenland.

The frequency of "low" and "high" magnitude "El Nino-Southern Oscillation" events have generally increased over the last 400 years. The frequency of severe events within the last 43 years has been 3-4 fold than that of 50 year intervals back to 1600 A.D. This increase in frequency of severe events is taken as evidence that atmospheric circulation is entering a state of atypical flux, at least in regards to historical times. The correlations of weather conditions in certain portions of the world with the presence of the El Nino, indicates the potential for predicting weather conditions several months in advance for certain areas of the world. These events exhibit low frequency and are quasiperiodic with events occurring every 3-4 years. Thus the probability greatly increases that an 'El Nino- Southern Oscillation' event will occur once 3-4 years has elapsed since the last event.

EVIDENCE FOR CONCERN

Over the last few decades the quality of Japanese products has steadily increased to the point that many of them are generally recognized as being in the world. Much of the credit to this economic miracle goes to the principles of quality control taught to them by Dr. E. Demming from the U.S. He had some very definite opinions about how products should be manufactured is companies were to remain competitive; however, hardly any U.S. company was willing to listen to his ideas. His concepts met a highly receptive audience in the Japanese. One principal that he advocated was the need to continuously monitor the variation associated in the manufacture of components and products, thus leading to methods that allowed manufacturers to determine when something was about to break. There is variability in all systems and this variability substantially increases as something begins to break or wear out. By monitoring this variability and the magnitude and frequency of events, one is able to become alerted to a problem before it becomes obvious. The following is a brief description of several events which either are exhibiting more variation than is typical or otherwise provides evidence of unexpected climatic changes.

A) Ice Core Project: This international project studies ice core from glaciers throughout the world, especially in Greenland, Chile, and the Antarctic. Scientists working with these cores have recently been astonished to find that the earth is capable of dramatic climate changes in one to three years. These findings also indicate that these changes were essentially worldwide. Some of these researchers conclude that "we're living in a world that has switches, and we don't know what they are. Flip a switch, and we get big climate changes. We humans are stumbling in the dark and might flip one of these switches". The last 10,000 years of climate has been remarkably stable, however based on the story preserved in over 250,000 years of layer upon layer of ice, there is substantial evidence that the climate of Greenland in particular and probably the earth in general has switched 35 times during this period of time and we are 8,000 years overdue for the next switching. "The earth's system is capable of jumping from one climate to another, and it's something we have to worry about. The message I get from this is, don't stick pins in the climate's tail. It's an ornery beast. Ice cores showed that very rapid changes occurred. The earth is screaming at us, "I can do it! I've done it before and I can do it again". The change is on the order of changing the climate of Duluth, MN, to that of Atlanta, GA, or vice versa, with little or no warning. These switches may include greenhouse gases such as carbon dioxide and methane, causing the Earth to warm, dust in the atmosphere which blocks sunlight, causing the Earth to cool, and other variables such as melting ice sheets and shifting ocean or atmospheric currents. Gases and/or dust ejected into the atmosphere from volcanic activity, especially when ejected into the upper atmosphere, are also likely candidates as triggers of these switches.

B) "Southern Oscillation" Events: As eluded to earlier, there has been a major increase in the frequency of "SO" events in the South Pacific since about 1600. This increase has been especially pronounced during the last 40 years. These events can lead to a proportional increase in the frequency of El Nino and La Nina events.

C) "La Nina and El Nino" Events: These event influence greatly weather patterns around the world, resulting in excessive rainfall or drought and abnormal temperatures. The frequency of these events have substantially increased in recent years with an exceptionally high frequency occurring within the last 10 years.

D) Increased Mean Atmospheric Temperature: The mean atmospheric temperature of both the Northern and the Southern Atmosphere has increased over the last 80 years, with the increase being especially noticeable in the Southern Hemisphere, which is where the bulk of the air mass is situated that is directly associated with the Southern Oscillation events.

E) Increased Concentration of Greenhouse Gases: The mean global concentration of carbon dioxide in particular has steadily increased from about 280 ppm to 380 ppm during the last 100 years. This rate of increase is accelerating and will continue to do so as long as fossil fuels continue to be oxidized.

F) Increased Frequency and Severity of Hurricanes and Typhoons: The frequency and strength of these storms are related to the energy gradients frond in the atmospheric ocean and between Earth's aqueous and gaseous oceans. The greater this gradient, the more and the stronger these storms will be. While it is not yet clear that this has happened, there is strong circumstantial evidence that this is about to become the case.

G) Increased Ejection of Volcanic Gases and Dusts: While there does not appear to be clear evidence that volcanic activity on the Earth is generally any different that it has been for many thousands of years, it is clear that the Earth is overdue for some of the really big volcanic eruptions that are typical at the historic level. Eruptions on the order of that of Tambura and others within the East Indies have not occurred within the lasts 100 years and are probably overdue. Eruptions 100-500 times more massive than that of Mt. St. Helens are not uncommon prior to a century ago and such eruptions today could possibly function as the finger that flips the switch which causes a shift in Earth's climatic characteristics.

H) Increased Frequency of Weather Anomalies: One thing for sure about the weather in most of the U.S. is that it can be depended upon to change; this is especially true in the Temperate Zone of our country. It is difficult to conclude from weather events that thing are changing and is therefore a very risky enterprise. However, based on precipitation records from the Georgia Pecan Belt from 1930-1991 precipitation anomalies have greatly increased beginning in 1989. This effect has been especially noticeable this July with the 500 year flood in Georgia. However, even without this recent flood, the frequency and severity of wet and dry periods in Georgia have been especially anomalous, perhaps being the major causal factor influencing the loss of nut yields in Georgia over the last 5 years.

There are a multitude of other weather events within the U.S. over the last few years (ex. November freeze, droughts in the southeast, floods and rain in the southwest, wet seasons, dry seasons, hurricane frequency, freak blizzards, etc.) which collectively exhibit substantial evidence for being more than just the normal variation in annual weather. The severity of the event combined with the short time table in which their occurrence has been compressed brings to mind the concept of variability as espoused by Dr. Demming. Things appear to be much more variable than in the decades prior to the last, and the frequency of these deviations appear to be much greater. This may be evidence that Mother Nature may be doing something she has done many times before, but we just weren't around to write about it. Could it be that Mother Nature is trying to tell us something? Could it be that the "climatic switch" has already been flipped and we are now only beginning to view the weather related changes associated with the transition from one climatic epoch to another? Or, is there still time to protect the switch or to reverse it if it has indeed been flipped? If it has already been flipped or is going to be flipped within a few years, how can the U.S. pecan industry prepare so as to minimize its impact?

PRECAUTIONS

It is anybodies guess whether the above described climatic shift is already taking place or will hold off for another million or so years. Until it becomes obvious that it is happening precautionary efforts may simply be a waste of time and perhaps money. But with an especially long-lived crop such as pecan , we pecan people have good reason to keep our eyes focused a good bit further across the horizon than do most folks.

What could we expect during the transitionary phases of such a change and what would pecan growing be like if it were to occur? Well, again it's anybodies guess. It is however probably safe to say that there will be both quantitative and qualitative abnormalities in factors relating to water, temperature, and wind. Rainfall and temperature characteristics can potentially cause problems with factors such as disease and insect populations, cold damage, hail and wind damage, vivipary, harvesting, nut quality, etc. In summary, one could say that it would be difficult to obtain stable production of reasonable quality nuts; this being similar to that which has been experienced in the southeastern U.S. since 1989. Abnormal weather events

will lead to higher levels of physiological stress to our trees. And as you know, pecan trees are hypersensitive to biotic and abiotic stresses, resulting in all of the problems associated with severe alternate bearing; therefore, alternate bearing would become much more severe of a problem than it is at present.

So what can be done to cope with these potential stress inducing factors? It appears to me that growers would be wise to buffer themselves from these potentially higher levels of stress by giving some serious thought to their cropping strategies, all with the ideal of minimizing tree stress. There are a several things that they could do.

These strategies should focus on addressing 'fixed' (those factors which can not easily be altered) factors that are associated with their orchard operations. This includes things such as tree spacing for increasing sunlight availability; establishment of cultivars which do not overcrop or can be fruit thinned if they do; cultivars that have the greatest resistance to the major pest such as scab, glomerella, leaf scorch, and black aphids; choice of cultivars which have proven to be most resistant to stress factors; use of cultivars with thick or naturally plump kernels and are of medium size or smaller (avoidance of large nut types, especially when they set more than 2 nuts per cluster); use of the most appropriate rootstock for the soils being cropped; and avoidance of cultivation of pecan or its particular cultivars near areas where the environmental conditions (such as length of growing season, cold hours, fall freezes, soil types, rainfall, etc.) are already marginal; planting four cultivars instead of the usual two so as to minimize the likelihood for losses associated with noncomplementary overlap of flowering due to abnormal chilling conditions; having plantings consisting of relative young trees rather than the more easily stressed older trees; establishing orchards in regions where pecan pests are already minimal; and avoidance of planting on sites where there is a high probability of exposure to hurricanes, tornadoes, or strong winds. Some 'nonfixed' factors that need to be seriously considered are factors such as optimumal nutritional management, optimum availability of water via irrigation, and techniques for fruit thinning; equipment being readily available for meeting the needs for the control of disease and insect pests; expertise in ecosystem management of pecan orchards; and avoidance of unnecessary debt. These buffeting factors are not all inclusive but should give a clear idea of just what growers might need to do to hedge their investments in pecan cultivation.

SUMMARY

As with any change in the environment, be it sudden or gradual, there is going to be pressure to change or to become extinct. It is my impression that there are a lot of pecan growers and affiliated folks that are already facing the prospects of extinction because of the stresses to which they have already been exposed. How much more stress is required before there is to be a major change in the nature of the industry? This is especially true for many growers in the southeastern U.S. as a result of crop losses linked to weather anomalies experienced from 1989 until the present. The pecan industry is undergoing evolutionary-like change and appears to be on the brink of being required to make drastic adaptations or many of its entities are destined to meet a fate similar to that of the dinosaur. Times of rapid environmental change and stresses is also a time of great opportunity to those who can rapidly adapt. I suspect that there is a very good chance that the future will afford conservative, moderately lucky, and horizon wary pecan folks a growth opportunity never before available since it is nature's law that the losses of one becomes the gain of another.

Well, this communication contains a lot of speculation and may possibly be of little or no significance; however, it addresses apparent facts and trends that may just possibly be of great importance, perhaps more than we can imagine. There seems to be just too much evidence to continue as if there was no cause for concern about the potential weather related problems that may be looming on the horizon. Only time will tell. It is hoped this brief accounting of observations and presentation of ideas has accomplished my objective of causing you to pause, look about, and think.