EFFECTS OF HARVEST AID MATERIALS AND TIMING ON PLANTING SEED QUALITY

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A DISSERATION

In

AGRONOMY

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Requirements for
the Degree of

DOCTOR OF PHILOSOPHY

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ACKNOWLEDGMENTS

First, I would like to express my thanks to my co-advisors, Drs. Norman Hopper and Randy Boman, for their support and encouragement. Likewise, it was an honor to have Drs. John Gannaway, Emmett W. Elam, and Richard E. Zartman serve on my committee. I wish to thank Dr. David Wester for his time and statistical knowledge in helping to complete this paper.

Next, heartfelt thanks are extended to my best friend and wife, Jaquita, for her support throughout this entire endeavor. Without the love and support of such a friend, the completion of this dissertation would have been impossible. Also, sincere thanks are extended to the rest of my family for their faithful encouragement during this project.

To my colleagues at Texas Tech and Texas A&M, I thank you for your support and help. Special thanks go to Ben Duesterhaus and Stacy Franklin for your help with the lab and field work and for your friendship. My appreciation and indebted gratitude also go to Lisa , Teresa Bryan and Toni Ridley for all your prayers and help in proofreading and editing this dissertation. Finally, I would like to thank Uniroyal for supporting this project. Without their funding and assistance, this research would not have been possible.

I dedicate this dissertation to the men of my former platoon and squad, from another time and another far-away place, who could only dream of an education and a life filled with love and happiness. I thank them for inspiring me to successfully complete my education so that I might, to some degree, fulfill the dream that we shared.

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ABSTRACT

The High Plains of Texas is a 22-county region that grows approximately 1.6 million hectares of upland cotton (*Gossypium hirsutum* L.) each year. In recent years, the cotton market has changed both domestically and overseas, and cotton growers are searching for new methods to improve crop yields. One method of increasing crop yields is to plant quality seed that is known to be vigorous. This method increases field germination and reduces the need to replant. Another method of preserving yields and quality is to apply harvest aid chemicals, which are used to prepare the cotton for an earlier harvest. With the changes in the industry, cotton growers have dramatically expanded their use of harvest aid chemicals in the last few years. Timely applications of these harvest aid chemicals are essential in avoiding premature loss of yield and seed quality.

The objective of this study was to investigate how applying specific harvest aid chemicals, at potentially sub-optimal 10% and 30% open bolls, may affect cotton seed quality and vigor. This knowledge could facilitate even earlier harvest dates, thereby possibly increasing growers' and seed companies' profits. In this project, harvest aid chemical treatments included ethephon (Prep®) plus tribufos (Def®), at 0.84 kg ai ha^{-1} each, and dimethipin (Harvade®), at 0.34 kg ai ha^{-1} and 0.51 kg ai ha^{-1} rates. These treatments were compared to an untreated check that had no chemical application and were left to the freeze. Also included was a paraquat (Cyclone®) control that had no

earlier chemical application; however, it was terminated by a paraquat application at 0.62 kg ai ha^{-1} at the same time the earlier chemical treatments were terminated (about 14 days after initial treatment). Four replicates were used in all field and laboratory studies. At harvest, a stratified boll sample was collected from each treatment and from the two controls. In each plot, the cotton plants were divided into upper, middle, and lower sections (strata). From each plot, fifty bolls were harvested from each stratum. After ginning, seed quality from these stratified sections was evaluated using the Cool-Warm Vigor Index (CWVI) and seed index. The CWVI uses the combined results from the Warm Germination Test and the Cool Germination Test. The seed index is determined by the weight, in g, of 100 delinted seeds.

The study was conducted at two locations in 1997 (Lubbock and Lamesa) and at three locations in 1998 (Lubbock, Seminole, and Olton). Data were analyzed by location using the GLM and Mixed Procedures in SAS. The untreated check was not necessarily the best method to use for chemical effect comparisons, possibly due to issues including maturity and preharvest losses. Therefore, the paraquat control generally produced more consistent results for comparing other chemical treatment effects. Stratified sampling results indicate, in general, that CWVI and seed index were adversely affected by the harvest aid chemicals at both timings of application. Dimethipin rates and treatments were generally not as detrimental as the ethephon plus tribufos to seed index. Lint yield results indicated that significant differences among treatments were noted at four of five locations. In general, the more aggressive ethephon plus tribufos treatment reduced lint yield and micronaire when applied at 30% open bolls or less. Even the less stringent

dimethipin reduced yield and micronaire at some sites. Results from this research indicate that significant reductions in seed quality (CWVI and seed index) can be caused by premature applications of certain harvests aid chemicals. There was no indication that the use of any of the treatments caused the enhanced movement of photosynthates into the seed which might result in a benefit of higher vigor or weight. In fact, quite the opposite was noted.

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CHAPTER I

INTRODUCTION

Historically, upland cotton (*Gossyplum hirsutum* L.) has been the crop with the greatest economic influence and impact on the Southern High Plains region of Texas. From the time these counties were first settled, cotton has been a staple in their economic development because it has reliably given growers a dependable cash source. Additionally, the High Plains area is a semi-arid region that produces enough heat units for cotton production. With irrigation assistance, this area can sustain dependable cotton growth even in years with little or no rainfall. Cotton's ability to grow under West Texas climatic conditions has firmly established it as a leading crop.

The ability to grow cotton would be of little value if no ready markets were available for the end crop. However, this is not a problem for cotton growers. Current market trends continue to demand more cotton-based products for use in the textile and yarn industry and in other markets such as soap, detergents, artificial leather, margarine, and vegetable oils. Advances in technology have also played a part in the growth of the cotton industry. Cottonseed hulls, which used to be viewed as a waste product, are now manufactured into fertilizer, fuel, and packing materials. Advances in agronomy have led to the ability to grow a higher quality of cotton on the High Plains. Therefore, in addition to providing cotton for denim, growers are now able to produce quality cotton that can be used in higher end cloth manufacturing.

In recent years, the expansion of cotton markets has created a boom in the cotton industry. Cotton is no longer just an isolated, regional crop. Due to the boom, interrelated businesses have developed to support cotton production. In this region, the most prevalent ones are banking, insurance providers, farming equipment and crop input suppliers, and cottonseed oil producers. Being exported throughout the entire world, cotton has also developed an international venue. In the last ten years, cotton marketing has shifted from a local market (the mills in the eastern part of the United States) to a world market, with China now being the single, largest consumer of American cotton fiber (National Agricultural Statistics Service, 2006).

On the High Plains, approximately 1.6 million hectares of cotton are planted annually (Texas Field Crop Statistics, 1981). The cotton harvested from these hectares accounts for nearly twenty percent of the total United States cotton crop (Texas Field Crop Statistics, 1981). This twenty percent of the nation's crop translates into billions of dollars of yearly income for the cotton industry. As the cotton industry's fiber and seed thrives nationally, so does the economic impact generated by this large amount of money. Since the impact achieved from abundant cotton crops has been such a widespread and pervasive driving force on the High Plains region's economy, it is vital that every measure be employed to gain increased yields and quality for each cotton crop planted.

Over the last few years, increasing costs of farm operations and a non-corresponding increase in the price of cotton have brought about a transition in the cotton industry. It has become a business of close margins. Growers have had to rely on more advanced technology to offset the rising costs of labor, materials, and low prices in the

national and world markets. Additionally, growers have had to become "crop knowledgeable" and employ more intense management techniques in order to achieve success in the cotton industry and to obtain reasonable profit margins.

How will growers be able to achieve continued high yielding crops? Examining this process begins, first, with the crop itself. There are two products normally processed from the cotton plant, the lint and the seed. Traditionally, lint has been the focus of cotton production. Lint is harvested and shipped worldwide for the production of a multitude of products. Formerly, the traditional focus on cottonseed was as a byproduct for animal feed. In the past ten years, however, the cottonseed focus has shifted to the growing and harvesting of quality cottonseed which can be pressed into oil for the food industry. For health purposes, this product has become recognized as a superior product over animal lard (O'Brien and Wakelyn, 2005). This shift in focus also includes growing quality cottonseed which is capable of producing even higher crop revenue.

The increased demands for higher lint yields and increased seed quality have led the cotton industry to focus resources on new research methods that will achieve increased crop yields and improved harvesting methods. This includes investigating the use of harvest aid chemicals. Harvest aid chemicals are traditionally applied to hasten the harvest and reduce potential losses in yield and fiber quality caused by inclement weather. The use of harvest aid chemicals is an avenue by which growers are able to achieve timelier cotton harvests. Timelier harvests ensure that crop yields (i.e., lint and seed quality) do not degenerate due to weathering. Harvest aid chemicals allow growers to increase their chances of obtaining uniform crop production from year to year.

Because of less weathering exposure to the crop, the proper use of harvest aid chemicals has brought documented results of earlier cotton harvests, increased preservation of fiber quality, and a higher seed quality (Supak, 1995).

The history of harvest aid chemicals originated in the South and dates back approximately sixty years. Cotton growers were looking for methods to harvest the cotton crop before the winter rains arrived. The method they developed employed the use of acid to chemically burn the leaves off the mature cotton plant. The idea was that the acid would defoliate the cotton plant and allow increased access to the cotton boll itself. The lack of leaves, on the plant, would then increase the speed at which the cotton could be harvested.

While the theory behind using acid as a harvest aid chemical had merit, the idea itself was better in theory than in actual practice. The technology was not available to evenly spray the cotton plants in large fields; therefore, the spraying produced inconsistent results on individual plants, properly desiccating the leaves of some plants while burning the crop on others. Also, the acid could be extremely dangerous to persons responsible for the application process.

The use of harvest aid chemicals in the High Plains region followed much the same ideology. Growers consistently tried to complete the cotton harvest before inclement weather reduced crop yield and quality. Due to the freezing temperatures present in this area, beginning in October or November, there was never any active interest in using these chemicals to achieve this goal. Farmers relied on the process of

the first freeze to naturally cause the defoliation of the cotton plant's leaves (Baskin et al., 1986).

However, during the 1990's, when the use of irrigation had increased and cultivars of cotton were more determinate in nature, the interest in using harvest aid chemicals began to be examined more carefully (Crawford et al., 1995). Due to a market change for the High Plains grower, interest in using harvest aid chemicals in the High Plains region also developed. Previously, the cotton of the High Plains was purchased only at loan value. The 1990's transformations in the cotton market, in spinning techniques, and in the mill technology around the world placed the High Plains region grower in a position to market higher quality cotton. To achieve the increased quality required, growers had to change their management tactics, which included a more timely harvest. Hence, the new interest in harvest aid chemicals.

The concept of using harvest aid chemicals grew from an idea to a widespread reality in approximately three years. Today, there are several chemicals on the market used for defoliantion and/or desiccation. These harvest aids are placed into the categories of defoliants, desiccants, or boll openers. One is also classified as a growth regulator. Each category has a specific function in relationship to what it achieves for cotton growers.

Knowledge of the various chemical capabilities and the environmental conditions to which crops are exposed is of paramount importance. This information enables cotton growers to bring the lint or seed into harvest and to obtain the highest yield and quality possible, thus reducing the chances of inclement weather adversely affecting the crop.

Ongoing research is of vital importance in aiding cotton growers to select appropriate harvest aid chemicals that are best suited for their particular areas.

To the end of increasing the knowledge base available for cotton growers, part of the research for this dissertation focuses on the harvest aid chemical named tribufos. Tribufos used in this study is marketed under the brand name Def®. The tribufos defoliant works by causing a release of ethylene in the cotton plant and injuring the leaf cells (Jost and Brown, 2003). This release of ethylene and its subsequent effect on the palisade cells results in leaf abscission. The reason for selecting this harvest aid chemical to use in this field-conducted research is because this defoliant (in conjunction with the boll opener ethephon—please see the next paragraph) is considered the standard, or most applied, harvest aid chemical used on the High Plains.

In order to accurately reflect the method in which cotton growers normally employ harvest aid chemicals, an ethephon boll opener (marketed under the brand name Prep®) is generally used in conjunction with the tribufos. This boll opener contains the chemical ethephon which converts to ethylene within the cotton leaves and bolls. Dependent upon environmental conditions and when applied at the proper rate to cotton that has a sufficient load of mature, unopened bolls, ethephon accelerates the boll opening process (Hope and Needham, 1987). A desiccant, paraquat (marketed under the brand name Cyclone®), was also employed in this experiment. Paraquat is a chemical that works by causing disruption of the cotton leaf's cell membranes, resulting in rapid moisture loss and subsequent desiccation (Boman et al., 2006).

A third chemical, a plant growth regulator is often utilized in conjunction with the other harvest aid chemicals. This plant growth regulator is dimethipin (marketed under the brand name Harvade5F®). Dimethipin is an herbicidal-type defoliant that provides effective defoliation of mature leaves but minimal inhibition of terminal regrowth (Jost and Brown, 2003). Dimethipin is less temperature-sensitive than phosphate defoliants and is reported to have better activity at lower temperatures. Dimethipin has traditionally been recommended in most states as a good cool-weather defoliant (Faircloth, 2007).

As mentioned earlier, the market for all cotton products has increased worldwide; however, the U.S. market for cotton has become less profitable in the last few years. This domestic decrease is due to increased production costs here in the U.S. and to a world market that generally keeps prices low. With these changes in the cotton market, it has become essential for growers to concentrate on factors that will enhance their chances of obtaining an increased profit margin from their crop.

To help increase profit margins, growers are concentrating on advanced biotechnologies available for cotton production, such as Roundup Ready (glyphosate-tolerant) and Bt (insect resistant) cultivars of seed; the use of harvest aid chemicals; and the advancement of mechanized harvesting equipment. Growers are also addressing the issue of how to limit labor costs. Even though these factors are all important for increasing profit margins, the most reliable factor for achieving increased cotton yields and higher profits is the usage of more expensive seed, either certified or transgenic. This higher quality seed reliably produces a higher yield per hectare overall (Baughman, et al., 2006).

The knowledgeable grower and seedsman realize that high quality seed is a necessity to give the cotton crop a superior start and to reduce the need for replanting. To ensure that they are obtaining high quality seed, growers depend on information gathered from laboratory tests that verify the quality of seed planted (AOSA, 1983). Additionally, accurate laboratory analysis of seed quality is of the utmost importance when anticipating the seeds' performance in field conditions relative to its germination success, the rate of emergence, and overall uniformity in plant growth (Wanjura et al., 1969).

Some of the most widely conducted laboratory tests include cool, cold, and warm germination trials performed in officially sanctioned laboratories (AOSA, 1983). These tests report the seeds' germination percent under a prescribed set of conditions. The warm test does not necessarily predict how the seeds will perform under actual field conditions. The cool (McCarty and Baskin, 2006) and cold (Duesterhaus et al., 1999) tests give a better indication of vigor and these tests provide data that closely correlates to field response. The need to provide an improved laboratory test for seed vigor and to provide the seedsman with an improved method of predicting seed performance in the field led to the development of the Cool-Warm Vigor Index test (CWVI) (Baskin et al., 1986).

The premise of the CWVI test is that it assists growers in knowing, to a greater degree, which seed lots should be used under various field conditions to achieve maximum benefits from the seed planted. This test has become extremely useful in determining high quality seed lots, which have a high potential for successful stand establishment under a wide range of field conditions (Delouche, 1980). The CWVI test has become widely accepted by growers as an accurate vigor test for cottonseed. In

conjunction with the CWVI test, there is an idea among some growers that if there was an increased photosynthetic transfer benefit into the seed, then a seed index test might also be an indicator of increased seed vigor.

Given the increased usage harvest aid chemicals have gained in today's cotton industry, it is vital that researchers determine the impact harvest aid chemicals have on seed quality since quality seed is the foundation for a successful cotton crop. Therefore, this study was conducted in order to determine the answer to two questions. Is seed quality affected by the use of harvest aid chemicals? What is the most efficient time for the application of harvest aid chemicals?

In considering what information would best benefit growers, the objectives of the study were as follows:

1. Evaluate the impact of common harvest aid chemicals on the resulting planting seed quality parameters,
2. Determine if the time of harvest aid chemical application for the different products, in relationship to boll maturity, alters the planting seed quality, and
3. Determine if seed weight loss occurs due to adjusted timings in harvest aid chemical applications.

CHAPTER II

LITERATURE REVIEW

With the high cost of seed and the introduction of biotechnology seed usage, planting seed quality has become an integral part of the cotton growing industry today. In order to maximize economic returns on their yearly crop, it is critical for growers to take advantage of planting timing and plant only once. Quality seed enables growers to do just that, thus allowing an adherence to critical timing schedules which lead to reduced overhead costs and increased net profits. Therefore, the ability to choose vigorous, quality seed is a vital concern to modern day growers (Hopper, 1981).

In recent years, one of the most important advents in determining seed quality is the use of vigor testing. Seed vigor information is necessary for growers to make accurate decisions regarding the type of seed to purchase, its cost, how early to plant, the quantity of seed to plant, and the expected uniformity of the cotton stand (Association of Official Seed Analysts, 1983).

The basic principle of seed vigor is relatively simple; however, the methods utilized to determine seed vigor can be complex. In the field, vigor is expressed as rapid germination, emergence, and seedling growth. The Association of Official Seed Analysts (AOSA) has adopted the following definition: "Seed vigor comprises those seed properties which determine the potential for rapid uniform emergence and development of normal seedlings under a wide range of field conditions." (McDonald, 1980)

When a seed achieves its maximum dry weight, it is said to be at physiological maturity. At this point in time, it has its greatest potential for maximum germination and vigor (Delouche, 1974). Cottonseed is not generally harvested until it dries; therefore, it reaches its physiological maturity and harvest maturity in the field, which aids in proper post harvest storage.

After harvest maturity is obtained, seed vigor may be affected by the amount of moisture to which the open boll is exposed. Sometimes mature seed weight losses of 20-30% have been recorded (Delouche, 1980). Hence, after the harvest process is completed, proper storage conditions are imperative if seed deterioration is to be kept to minimal levels. There are three distinct phases of storage for cottonseed, with time, temperature, relative humidity, and oxygen being important in each phase (Delouche, 1981; Roos, 1980).

The first storage phase spans the time period from the harvesting of the cotton to its arrival at the cotton gin. There are no uniform conditions or methods used during this first phase. Cotton is harvested under many different conditions, several of them far from ideal. These conditions range from hot and wet to cool and dry and they exist across the Cotton Belt. The harvesting equipment is not standardized. Either strippers or spindle pickers are employed. Also, the cotton is stored under different types of storage conditions, although trailers or modules are usually used. Fewer trailers are used due to the wide spread adaptation of module builders. An important part of this storage can be the use of proper module covers that will protect the lint and seed quality (Searcy et al.,

2003). All of these parameters can affect the seeds' quality, either by increasing deterioration of the seed or by preserving its quality.

The second phase encompasses the time period from the ginning of the cotton to the period of time when it is prepared for delinting. During this phase, seeds can be mechanically damaged by gin equipment. It is also the phase where seeds are stored in mass and can be exposed to various environmental conditions that may affect the quality. For example, high temperatures and elevated moisture conditions may cause seed deterioration and lower seed quality by causing the break down of enzymes (Delouche, 1980).

The third phase, and many times the most critical phase in maintaining seed vigor, is the time frame that extends from the delinting of the cottonseed to its packaging and storage for shipment (Roos, 1980). Delinting the cottonseed is accomplished using acid (wet or gas). This process can cause significant damage to seed vigor as a result of the heat and/or moisture employed during delinting. Additionally, high moisture levels, sometimes found in storage facilities, increase the rate of seed deterioration (McDonald and Phaneendranath, 1978). An increase in storage facility temperatures also hastens the deterioration processes in cottonseed (Abdul-Baki, 1980).

Other than the factors produced by seed storage, there are also naturally occurring, biochemical changes produced in the seeds during storage. These changes include the oxidation of lipids, the loss of membrane integrity, and a reduction in enzymatic activity (Roos, 1980). Taking these naturally occurring processes into account, as well as the factors involved in all the phases of storage, it is evident that the

need exists for a seed vigor test that will measure seed parameters and predict seed performance in the field. To provide a reliable benchmark, this seed vigor test needs to take into consideration the factors that influence seed vigor. These factors include the seeds' genetic constitution, the environment in which the seed developed, and the method that was used to store the seed. The harvest aid application timing and chemicals used to terminate the cotton plants may also be factors.

As per industry standards, various tests that are aligned with established seed growth criteria have been developed to determine the quality of the cottonseed (AOSA, 1983). The cutting test is a quick method to determine mature seeds by visually noting the color of the seed embryos and seed coats (McCarty and Baskin, 1993). The visual mechanical damage test method inspects the seed coat, determines any damage present, and then classifies the severity of the damage. Seed coat damage causes a reduction in seed germination. The seed coat maturity test identifies the maturity of the cultivar, or lot of seed. The standard germination test evaluates the percent of seeds that will germinate for the seed lot in question (AOSA, 1978). The tetrazolium test estimates seed germination and vigor by the use of an enzyme that reacts to the live tissues of the seed (McCarty and Baskin, 1993). The conductivity test method passes an electric current through seeds immersed in water and notes the electrical conductivity of the water in which the seeds have been soaked (McCarty and Baskin, 1993). The free fat acidity test is generally performed while the seed is in storage but prior to delinting. This test demonstrates the condition of seeds based on their oil or free fatty acid content (AOSA, 1978). The cool, or cold, temperature germination test demonstrates the vigor qualities of

the cottonseed when exposed to suboptimal temperatures. The accelerated aging test determines the vigor and germination of cottonseed by subjecting seed to a pre-test of 41.6 ^{0}C for seventy-two hours before germination and noting the percentage of seeds that germinate (AOSA, 1978).

Any seed vigor test should employ the standards of being (1) rapid, (2) simple, (3) reproducible, (4) interpretable with results that will correlate with emergence under field conditions, (5) objective, and (6) economically practical. Several seed vigor tests are used in combination with each other in order to obtain information on several different seed quality components (AOSA, 1967). These components may involve the emergence force, the rate and the totality of seed germination, and the seeds tolerance to environmental or disease-related stresses.

The two tests utilized for this project were the standard warm test and the standard cool test. The combination of these two tests produces a seed vigor test (CWVI) that meets all the criteria required for an outstanding vigor test for cottonseed. It is practical in application and is economical enough to be able to be utilized by the cotton industry.

Crop rotation is the most effective tool in preventing seedling disease, but seed quality is the next most important criteria in order to maintain a healthy start for the cotton seedlings. Utilizing the CWVI test is an important method of demonstrating the hardiness of cotton seedlings and their ability to withstand disease and fungal invasion. Therefore, having the data from the CWVI is the first line of defense in controlling these pathological problems before they start (El-Zik et al., 1993).

The need for a CWVI test was demonstrated years ago. Dr. Norman Hopper at Texas Tech University, located in Lubbock, Texas, developed a CWVI test that utilized a combination of the two separate tests mentioned above to determine the vigor of cottonseed. The reliability of these two tests has been verified by the Texas Department of Agriculture, a state government agency that has performed and standardized these tests for many years (TDA, 1998).

The Standard Germination Test is the most common diagnostic tool utilized in cottonseed testing and is conducted under optimum conditions for seed germination, which are duplicated in the laboratory (Yacklich and Kulik, 1979). When field conditions are near optimum, laboratory tests will correlate well to field emergence. However, field conditions are seldom optimal. The Standard Germination Test results, therefore, are usually unable to accurately predict the field performance of a seed lot (Tekrony and Egli, 1977).

The Standard Germination Test (also known as the Warm Germination Test) is conducted under laboratory conditions and employs ideal temperature and moisture conditions proven to be optimal for the germination and the development of the cotton seedlings (Yacklich and Kulik, 1979). This test is conducted using 50 to 100 cottonseeds per replication. The seeds are placed between wet towels and then rolled up and securely closed. These bundles are placed upright into the germinator on their end, to allow for the drainage of excess moisture. The temperature in the germinator is set to alternate between 20-30^{o}C. The germinator operates for 16 hours at a temperature of 20°C. It then switches to a temperature of 30°C for the next 8 hours. After the 8 hour period, the

germinator switches back to a temperature of 20° C and the cycle repeats itself. The rationale for employing the varying temperatures is to simulate the different day and night temperatures found in field conditions.

The first evaluation of the seedlings' response to the above stated conditions is conducted four days after implementing the test. The seed bundles are removed from the germinator, and the towels are carefully unrolled. The seeds are examined. Seeds that have developed a radicle that is at least 3.8 cm in length and that have acquired a normal physiological and anatomical condition are counted and discarded (Staus and Hopper, 1984). The remaining seeds that have not yet obtained the above mentioned criteria are rolled back in the towels, securely closed, and put back into the germinator.

A second evaluation is performed eight days after implementing the test. On the eighth day, the towels are again removed from the germinator, unrolled, and the seeds are visually examined. The seeds that meet the above criterion are again counted and discarded. Depending on the requirement of additional data, a final evaluation can be performed twelve days after the start of the test. When the final set of seed examinations has been performed, the number of normal seedlings produced in each set is totaled together. The percentage of germinated seeds is then calculated and reported as the percent germination. Typically three to four replications are employed.

Another test that is employed to assist in determining seed vigor is the Cool Germination Test. This diagnostic tool is a stress test that was specifically developed for vigor testing cottonseeds. In a similar style to the Standard Germination Test, seeds are incubated in the germinator and again rolled up in secured wet towels. These bundles are

then placed upright into the germinator on their end, to allow for the drainage of excess moisture. The difference in this test is that the seeds are incubated at a constant temperature setting of 17.8° C for seven days. The determination for using this temperature setting is based on data that the minimum temperature at which cotton will germinate is approximately 15.6° C. Conducting the test at a constant, low temperature is done because research has demonstrated that the influence of constant, low temperatures on seeds may induce radical injury and increase their susceptibility to microorganisms (McCarter & Roncaddri, 1970). Seeds that withstand this test and continue to develop, even under this adverse condition, demonstrate their vigor as opposed to seeds that do not show any developmental traits. Thus, this test produces a separation of vigorous and nonvigorous seeds.

Again, in a similar fashion to the previous test, the seeds are evaluated. This evaluation is only done once, at the end of the seven day period. A count, again using the criteria of radicle length and normal appearing physiology and anatomy, is made to determine the percent of germination.

Once completed, the Warm Germination test results obtained after four days incubation time and the Cool Germination Test results obtained after seven days incubation time are combined by adding the percent germinations of both tests. Combining the two sets of data produces the CWVI score (Hopper et al., 1988). As discussed previously, the principle behind the CWVI test is to provide information regarding the vigor level of a seed lot under circumstances that more appropriately mimic

actual field conditions. This test combines warm germination and cool germination conditions to that end.

From the data obtained, the CWVI then applies a rating index of Excellent, Good, Fair, or Poor, depending on the final score calculated from the test results. A rating of Excellent is given if the score is 160 or greater; a rating of Good is given if the score is 140-159; a rating of Fair is given if the score is 120-139; a rating of Poor is given if the score is 119 or lower. This rating system enables growers to quickly discern the category of a seed lot, thus making the CWVI test the most dependable test in the cotton industry for establishing seed vigor and, thereby, predicting the resultant vigor of the stand (Hopper et al., 1988).

Research has shown that, "…cool weather is the most important factor influencing seedling vigor and stand establishment." (Knowles and Wakimoto, 1997) Knowles and Wakimoto's research suggested that the large-seeded cotton cultivars such as Stoneville and Sure Grow, when planted into cool soil, have a much higher emergence rate and seeding vigor in comparison to the relatively small-seeded Deltapine cultivars. All of the results from their data showed that the optimum planting date for heat units is an early one in the season. However, when using an early planting date, growers should also consider the soil temperature, the current weather conditions, and the cultivar of seed being used (Knowles and Wakimoto, 1997).

Additionally, cotton plant vigor was discussed in relationship to the CWVI, and it was determined that growers can request information regarding the test results of a warm and a cool test. The combined data from both of these tests will help the grower

determine the true vigor index of their own cottonseed or cottonseed lots purchased for planting. Cottonseed with a CWVI above 155 should be the only seed planted when cool, soil temperatures (a minimum of (15.5^0 C), are indicated at planting time (Warrick, 2001).

The microclimate of the cotton's growing environment is a major factor in the production of quality cottonseed. A large microclimatic factor for the High Plains area of Texas is high wind that cotton plants, in some areas, must endure. Strip cropping, where larger plants are planted adjacent to smaller ones, can effectively protect the smaller plants from the debilitating effects of the wind in those areas where windy conditions are a major environmental factor. Most wind damage occurs during the first three to six weeks after the seedlings emerge (Hake et al., 1991). However, in the High Plains region, the planting of high vigor seed will get a crop off to a good start despite the windy conditions prevalent during the early growing season (Hake et al., 1991).

Due to the time involved in conducting cottonseed testing, the expense associated with the testing, the fact that some of the more complicated seed tests are difficult to interpret, and the possibility of an occasional measure of error associated with a test, there are those who have looked for an easier or shorter method of determining seed germination percentages, aside from employing standard germination tests. One of the simplest and least expensive ideas that has been discussed is the correlation of seed weight or density to germination results. This idea has been tested and has been found to be much less reliable than the CWVI in determining the vigor of the cottonseed tested (Bartee and Kreig, 1972).

Vigor of the seed may also be explained by the weight of the seed, which is commonly referred to as the seed index (weight, in grams, of 100 fuzzy seed). The method employed in establishing the seed index in this study was to weigh a hundred delinted seed obtained from each treatment. Treatments are defined as (1) the application of each harvest aid chemical to the cotton plant and (2) the timing of each chemical's application to the cotton plant. This project utilized the weight of a set quantity of seed to determine the seed index, rather than utilizing the more complex density test. Next, testing was performed between the treatment sets to determine the resultant seed index for each treatment set and to ascertain if there was a significant vigor associated with a heavier seed weight.

Karl Sax presented the first evidence that a linkage existed between genes controlling qualitative traits (seed color or color patterns) and genes controlling quantitative traits (i.e., seed weight) (Sax, 1923). Specifically, he was able to identify, in common bean seeds, this genetic relationship for seed weight through an association between seed weight and seed color. There is no reported association like this in cotton.

Another study pertaining to seed weight has been done with the winterfat (*Ceratoides lanata*) shrub, which has a height of one to three feet and is commonly referred to as silver sagebrush (Hou and Romo, 1998). When this shrub is planted for the restoration of range land or land that has been strip mined, relatively heavy seeds should be utilized for planting, as these seeds have the highest germination rate and produce large seedlings that exhibit a high viability rate as well. Research demonstrated that the seedling length of winterfat was enhanced with increasing seed weight, thus

proving the desirability of selecting heavier seed. However, reduced germination in seeds may necessitate increasing the seeding rate (Hou and Romo, 1998).

The True Potato Size (TPS) combinations, developed from parental lines that produce higher proportional yields of large seeds (0.157cm or greater), should be selected for field trials (Upadhya and Cabello, 1996). Some of Upadhya and Cabello's field trials showed promise that the bigger and heavier seed would increase the percent of germination, but no correlation between the seeds' weight and its germination rate was ever established with trial documentation.

In this study, the Cool Warm Vigor Index and the seed weight index were utilized to reliably predict the effect that treatments might have on seed vigor. It was hypothesized by Uniroyal sales department that dimethipin, a plant growth regulator, reportedly causes a transfer of weight that enhances the maturity of the boll through additional available photosynthates. Assuming that the greatest sink for these photosynthates would be the seed, the weight of the seed may differ between treatments depending on which harvest aid chemical is utilized. The timing of the application of the harvest aid chemicals is also important. Typically, late-season seeds weigh less and have a higher oil-to-protein ratio than do early-season seeds (Nelson, 1949). Cotton has a long span of development time per season, and it is theorized that the early, or first, fruits of the plant would not receive any benefit from the application of harvest aid chemicals.

As previously discussed, harvest aid chemical utilization was attempted early on, but there was little interest in their usage in the High Plains region because of the natural, terminating effect of winter frost. Now, however, with the advent of irrigation and the

introduction of cotton cultivars that are more determinate in nature, the interest in utilizing harvest aid chemicals has been renewed (Crawford et al., 1995).

As a result of this new interest in and the market for harvest aid chemicals, research has been conducted to determine the most beneficial application times, rates, and combinations of harvest aid chemicals (Brecke et al., 2001). Research has demonstrated that the optimum combination of harvest aid chemicals is achieved with two applications. First, an application of ethephon and tribufos with no additional desiccant is needed. Second, a sequential treatment of parquat is applied. According to A. D. Brashears, formerly with the United States Department of Agriculture, Agriculture Research Service, "…these treatments give the producer several options in preparing the plant for early harvest with brush roll harvesters." (Brashears et al., 1997)

Recently, cotton growers have expanded their usage of harvest aid chemicals. In 1992, less than 30% of cotton acreage was treated. However, by 1995, that figure augmented to over 80% (National Agricultural Statistics, 1995). The increase in usage on the High Plains, a region that generally produces its own planting seed, has raised concerns about the impact that harvest aid chemicals, both the application process and the timing process, have on planting seed quality (Hake et al., 1990). Due to the increased cost of certified and transgenic planting seed and the grower's desire to achieve optimum stands with reduced seeding rates, this possible impact has validity and deserves consideration.

Newly registered and utilized chemicals, with different modes of action, have become standard treatments for defoliation, desiccation, and boll opening. Previous

scientific research has demonstrated that harvest aid chemicals are generally applied to hasten the harvest of a mature crop and to reduce those potential pre-harvest losses of lint yield and fiber quality (Supak, 1995). Proper use will result in earlier harvest, preservation of fiber quality, and fewer seed quality reductions due to field exposure (Snipes and Baskin, 1994). Additionally, four harvest aid chemicals, which included defoliants, desiccants, and boll-openers, have been tested to determine the effect their usage produced in the storage of seed cotton. The study demonstrated cotton treated with harvest aid chemicals could be stored without any apparent loss of fiber quality (Brashears et al., 1997).

One of the most important factors to consider when using harvest aid chemicals is plant maturity. Harvest aid chemicals can retard the growth of the cotton plants; therefore, the grower should ensure that 60-70% of the cotton bolls are already open before applying a desiccant product. There are several ways to determine crop maturity. The most recently developed method involves the counting of nodes above a cracked boll. If the uppermost, first-position cracked boll is within three nodes of the uppermost, harvestable first-position boll, no lint weight will be lost if a defoliant-type harvest aid is applied at that time (Boman et al., 2006). Another method is to count 100 plants and determine the percentage of open bolls. The last method involves cutting the bolls with a sharp knife; the boll should be difficult to cut, and the seed coat should be a dark color (Jost and Brown, 2003). If the harvest aids are applied before the bolls are mature, the producer will probably have a loss in yield and quality.

The maturity time line is an important component of this project. Is the applications at 10% open boll application too early, or are both applications at 10% and 30% open bolls too soon in the maturity of the cotton for the proper development of lint or planting seed quality? This project utilized earlier open boll options (before the 60% open boll normally recommended) in an effort to determine if a difference existed between 10% and 30% chemical applications. Two checks were also used in this project. One check was left until terminated by a freeze or frost, and the other check was terminated by paraquat at the time of the chemical treatments. Results from the check sites were compared to each other and to the results from the chemical sites.

There are particular combinations of harvest aid chemicals that prove beneficial in preparing cotton plants for early harvest, while still maintaining lint quality. Employing early applications of ethephon and tribufos followed by a treatment of paraquat produced the best overall lint grades. The combination of these chemicals allows several options when considering early harvest (Dever et al., 1993). This ability to harvest early, while retaining lint quality, explains the factors that helped influence the increased utilization of harvest aid chemicals in the High Plains region.

The types of harvest aid chemicals available to growers include boll openers, defoliants, and desiccants (Boman et al., 2006). Boll openers are primarily products that contain ethephon. When applied at the proper rate to cotton that has a sufficient load of mature, unopened bolls, ethephon stimulates production of ethylene and accelerates the boll opening and defoliation processes (Pettigrew et al., 1993). There are several chemicals utilized for defoliants. Tribufos is one which causes a release of ethylene, thus

injuring the palisade cells of a plant's leaves, resulting in leaf abscission (Cothren, 1999). Paraquat is a desiccant that causes rapid moisture loss by disrupting the leaf cell's membranes through the production of super oxide (Supak, 1991). Of note, dimethipin is the only harvest aid chemical currently on the market that is both a defoliant and a plant growth regulator.

The harvest aid chemicals utilized in this study were ethephon, tribufos, paraquat, and dimethipin. Ethephon was employed as a boll opener. When applied at higher rates, it often enhances defoliation of the cotton leaves. This may result in an earlier harvest as well as a more efficient once-over harvest (Hope and Needham, 1987). Ethephon also promotes the premature dropping of small, immature bolls. Therefore, growers should be careful to ensure that a sufficient number of mature, unopened bolls are present when ethephon is applied so the desired yield and quality are obtained. Furthermore, because ethephon causes the smaller, immature bolls to drop prematurely, it has been effective in managing pink bollworms since immature bolls are hosting sites for these pests (Ball and Glover, 1999).

Ethephon also accelerates the opening of cotton bolls (Hope and Needham, 1987). This increase in the rate of boll opening has allowed harvest operations to begin several days earlier. The earlier harvest allows for an increase in the percentage of the crop harvested during the first picking and often eliminates the need for a second harvest in many fields. The crop, however, should be well matured prior to the use of ethephon to avoid a reduction in fiber quality. No adverse effects have been noted from ethephon-treated treatments on lint quality, grade, staple, micronaire, and percent lint turnout;

however, there have been reports of lower micronaire if ethephon is applied prematurely on immature cotton (Boman et al., 2006). To obtain maximum results, ethephon should be applied when the last harvestable bolls are mature and before 40-60% of the bolls are open. The most common method of determining boll maturity is to squeeze the boll between the thumb and fingers; a mature boll will not dent (Boman et al., 2006). Another method is to slice the boll with a sharp knife. When it is sliced, the seed coat in a mature boll should be light brown (Glover, 1992).

Since defoliants cause only the leaves of the cotton plant to abscise, they are applied to cotton to improve and facilitate mechanical harvest (Ball and Glover, 1999). Under normal weather conditions, tribufos produces effective defoliation of the cotton leaves within four to seven days. The leaves of the cotton plants do not appear affected until defoliation actually begins. Growers should utilize the higher recommended application rate when conditions of continuous low temperature, low humidity, or plant stress exist (Ball and Glover, 1999). With continuous low temperatures prevalent at night (below 15.6^{o} C), complete defoliation of the cotton may require a longer period of time, typically nine to fourteen days. (All applications should be scheduled in accordance with local recommendations). Tribufos should not be applied to immature cotton leaves (less than 60% open bolls). Environmental conditions dictate the need to adjust application rates applied. Otherwise, high temperatures and other environmental conditions may cause desiccation or leaf freezing (leaves do not drop off the plant).

The desiccant paraquat, also known as dichloride salt of paraquat, is a herbicide widely employed for broadleaf weed control. It is a quick-acting, nonselective compound

that destroys green plant tissue on contact by translocating water out of the cells. This product is utilized to completely kill the cotton plant and dry it out so machine harvesting can be easily achieved. It is usually the last chemical applied during harvesting.

Dimethipin is a hormonal-type defoliant that produces defoliation of the cotton leaves, but it has a minimal affect on terminal regrowth (Jost and Brown, 2003). It is less temperature sensitive than other phosphate defoliants, and it has better activity at lower temperatures. In some cases, dimethipin has demonstrated the ability to desiccate morning glory (Jost and Brown, 2003). Dimethipin generally provides defoliation equivalent to that of the phosphate-type materials. Unlike some chemicals, dimethipin is shown to be less sensitive to low temperatures than other defoliants. Dimethipin is a unique plant growth regulator derived from a new area of chemistry discovered in Uniroyal's laboratories. Dimethipin has been shown to be a true plant growth regulator that not only defoliates the cotton plant, but it also accelerates the natural maturing processes (Hegman, 1983).

CHAPTER III

MATERIALS AND METHODS

The objectives of this study were (1) to evaluate the impact of common harvest aid chemicals on the resulting planting seed quality parameters, (2) to determine if the time of harvest aid chemical application for the different products, in relationship to boll maturity, alters the planting seed quality, and (3) to determine if seed weight loss occurs due to adjusted timings in harvest aid chemical applications. Field experiments were conducted in 1996, 1997, and 1998, but only the 1997 and 1998 data were analyzed and reported in this dissertation. The study employed the CWVI and the seed index to determine the results.

Two test sites were initiated in 1997. The first site was at the Texas Agricultural Experiment Station (TAES), located near Lubbock, Texas. The TAES site consists of Acuff sandy loam soil type (fine-loamy, mixed, superactive, thermic Aridic Paleustolls). The second site was located at the Lamesa Cotton Growers Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) Farm located near Lamesa, Texas. The AG-CARES Farm consists of an Amarillo fine sandy loam (fine-loamy, mixed, superactive, thermic Paleustolls).

In 1998, three test sites were initiated. The first site was at the Texas Agricultural Experiment Station, located near Lubbock, Texas. The second site was in a producer field located near Seminole, Texas. This site also consisted of an Amarillo soil type (fine, sandy loam). The third test site was located in a producer field near Olton, Texas,

and was comprised of an Olton clay-loam soil type (fine, mixed, superactive, thermic Aridic Paleustolls).

The treatments at all locations were arranged in a randomized complete block design utilizing four replications. The plot sizes were four rows, 1.01 meters wide by 12.1 meters long. The treatments included (1) dimethipin applied at a rate of 0.34 kg ai ha^{-1}, (2) dimethipin applied at a rate of 0.51 kg ai ha^{-1}, and (3) ethephon at 0.84 kg ai ha^{-1} plus tribufos applied at a rate of 0.84 kg ai ha^{-1}. The treatment applications were performed at two separate times, the first at 10% open boll and the second at 30% open boll. All treatments used in this study (except the untreated check) were terminated with paraquat at a rate of 0.62 kg ai ha^{-1}, fourteen days after the 30% open boll treatment. Each test site had two check treatments. One check treatment received paraquat at the same time as the paraquat termination of the other harvest aid treatments. The other check treatment was left in the field until a natural freeze occurred. The two check treatments were valuable because the one harvested at the same time as the other treatments gave a comparison to the different chemical and timing treatments, and the check terminated by a freeze gave a comparison to yield, micronaire, and seed quality of maximum maturity.

The cultivar utilized during the 1997 growing season at all locations was 'Paymaster HS26'. The planting dates for the 1997 growing season were May 6th at the Lamesa location and May 24th at the Lubbock location. The cultivars utilized during the 1988 growing season were 'Deltapine 5409' for Seminole, Paymaster HS26 for the Lubbock test site and 'Paymaster 145' for the Olton site.

The planting dates for the 1998 growing season were May 12th at the Seminole location, May 8th at the Lubbock location, and May 10th at the Olton location (Table 3.1).

Table 3.1. Planting, application, and harvest information for all locations.

	Year				
	1997		1998		
Variable	Lubbock	Lamesa	Lubbock	Seminole	Olton
Planting date	24-May	6-May	8-May	12-May	10-May
Cultivar	Paymaster HS 26	Paymaster HS 26	Paymaster HS 26	Deltapine DPL 5409	Paymaster PM 145
	Application date				
10% Open Boll	19-Sep	12-Sep	16-Sep	15-Sep	15-Sep
30% Open Boll	25-Sep	18-Sep	23-Sep	22-Sep	22-Sep
Paraquat (termination)	10-Oct	6-Oct	10-Oct	7-Oct	8-Oct
Harvest data (treatments)	27-Oct	20-Oct	18-Oct	27-Oct	20-Nov
Harvest data (control)	10-Nov	30-Oct	23-Nov	23-Nov	20-Nov

During the 1997 and 1998 growing seasons, each test site was managed in a manner similar to the style used by area growers to manage their own cotton fields. Preplant herbicides and all cultivation and farming operations were performed in accordance with normal area practices. The preplant herbicides were applied at normal rates normal for each area, in accordance with that specific test site's soil type and geographical location. The irrigation methods implemented at each site differed. The TAES and Olton site employed the furrow irrigation technique, while the AG-CARES Farm near Lamesa and the Seminole site both used center pivot irrigation systems.

Environmental conditions during the two test years were atypical for the region. Typically, heat units in the test areas average from approximately 982 to approximately 1260. However, the heat units for the 1997 and 1998 growing seasons were above normal, averaging approximately 1315 heat units. This average was about 149 to 204 heat units above the 1093 heat units required for cotton to properly mature during the May to mid-September growing season (heat units calculation (high + low) /2 – 15.5^0 C base temperature).

Additionally, rainfall for the 1997 growing season (May- September) was below average, measuring 11.07 cm during this time period; typically rainfall averages 25.4 cm during the growing season. During the 1998 growing season, the rainfall was closer to average measuring 21.6 cm, which is still slightly below typical levels. All the test site locations for both growing seasons had atypical warm and open falls with little or no rain to interfere with the harvest.

Chemical applications were made utilizing a Spider self-propelled sprayer manufactured by the West Texas Lee Company based in Idalou, Texas. The Spider was equipped with a boom sprayer that was set to deliver 140.25 L ha^{-1} of chemical solution traveling at a rate of 1.34 ms^{-1} with a pressure of 165.6 kPa. The nozzle spacing on the boom was set to a distance of 50.8cm between each nozzle, and it was equipped with Teejet® XR11002 flat fan nozzles positioned to spray approximately 0.5m above the cottons' canopy.

The harvest aid chemicals applied in 1997 and 1998 consisted of (1) dimethipin, (2) paraquat, and (3) ethephon plus tribufos. Treatments 1, 3, and 5 (Table 3.2) were applied when approximately 10% of the bolls were open, while treatments number 2, 4, and 6 were applied when approximately 30% of the bolls were open. Fourteen days after the 30% open boll application, the termination application of paraquat at 0.62 kg ai ha^{-1} was applied to all of the treatments, with the exception of treatment 7. This treatment was the untreated check, left to the natural freeze (Table 3.1).

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Table 3.2. The 1997 and 1998 harvest aid treatments for all locations.

Treatments
1) Dimethipin 0.51 kg ai ha^{-1} at 10% Open Boll
2) Dimethipin 0.51 kg ai ha^{-1} at 30% Open Boll
3) Dimethipin 0.34 kg ai ha^{-1} at 10% Open Boll
4) Dimethipin 0.34 kg ai ha^{-1} at 30% Open Boll
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10% Open Boll
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30% Open Boll
7) Untreated check
8) Paraquat control 0.62 kg ai ha^{-1}

ai-active ingredient.

Duplicate chemical treatments were performed during both the 1997 and 1998 tests. Due to the differing environmental conditions between the two years, an analysis of the data determined that the test results from all locations across both years could not be statistically combined. Therefore, analysis of the resulting data from each year and location was evaluated separately; i.e., the resulting test data from each year and location were analyzed individually.

Harvesting of all treatments was a stratified hand harvest, except for the yield and micronaire. The composite harvest of yield and micronaire was by a converted John Deere 482 cotton stripper. Grab samples were taken and ginned on a 10 saw gin at the TAES to determine gin turnouts. Lint samples were submitted to the International Textile Center at Texas Tech University for HVI fiber analysis.

Seed utilized in the CWVI test and the seed index test was hand-harvested in accordance with a stratified sampling technique that used three strata of random plants. These plants were selected from the two middle rows of each of the plots. Within these two rows, the bolls on each selected cotton plant were harvested by strata. The upper one-third of the plant was designated as Stratum 1. The middle one-third of the plant was designated as Stratum 2 and the lower one-third of the plant as Stratum 3. Throughout the plot, fifty first-position bolls were randomly harvested from each stratum.

After careful harvesting from each stratum, bolls were ginned on a 10-saw laboratory gin at the TAES and the seed was saved for delinting. All of the seeds were delinted at the delinting laboratory located at the TAES. Sulfuric acid was used to dissolve the linters from the seed coat. In the sulfuric acid method of delinting, the

sulfuric acid was exposed to the seeds only long enough to remove the lint from the seed coat. Once this was achieved, the seeds were immediately neutralized with a soda and water mixture. The seeds were then rinsed completely with clear water until no sulfuric acid or neutralizer remained on the seeds, and they were completely clean.

Following delinting, the seeds were promptly spread in a single layer on drying trays with wire bottoms, which allowed the heated air to circulate around all surfaces of the seeds. This method of quick drying did not allow the seeds to imbibe water. After the drying process, the seeds were stored in a cool, dry environment until time to perform the germination tests.

Before performing the germination test, each stratum sample was cleaned utilizing a 757 South Dakota Seed Blower, which is manufactured by the Seedburo Equipment Company located in Chicago, Illinois. This seed blower produced a column of upward airflow that lifted and rotated the seed allowing the ultra lightweight seeds, as well as any existing trash, to be trapped in the top partition of the blower's catch unit. Following this cleaning process, each sample of seed was placed in an automatic seed counter and 100 seeds were counted so that the corresponding seed weight could be established and recorded.

The Warm Germination Test, which is a portion of the CWVI test, was conducted under AOSA guidelines that require the use of alternating temperatures of 30^0 C for an eight hour period followed by a temperature of 20^0 C for a sixteen hour period. Two randomly selected samples, consisting of fifty seeds per stratum from the four replications for each treatment**,** were placed on wet standard germination towels with the

seeds located at even intervals. The towels were rolled up into a log roll, tied with rubber bands to retain their shape, and placed upright in the germination chambers on their narrow ends to allow for the drainage of excess water. The germination chambers were set at the aforementioned temperatures.

The towels were removed from the germination chambers, unrolled, and germination counts were conducted four days and again at seven days after the test's onset. (The towels were rerolled, retied, and set upright back in the chambers in between these two counts.) On the fourth and seventh days, the seeds that had successfully germinated, that had a normal, healthy physiological appearance and anatomy, and that had achieved a combined hypocotyl and radicle length of 3.81 cm (or longer) were counted and recorded. After the germination count was conducted, the seeds were discarded. The recorded seed count from the fourth test day is critical information that is combined with results from the Cool Germination Test counts to determine the CWVI of the seed.

The Cool Germination Test was also conducted under AOSA guidelines, which require a constant temperature of 17.8^0 C for a period of seven days. The seeds were placed at even intervals on wet, standard germination towels. Again, the towels were rolled up from their narrow end, tied, and placed upright in the germination chambers at the aforementioned temperature. At the end of seven days, the towels were untied and unrolled, and any normal germinated seedling with a combined hypocotyl and radicle length of 3.81cm (or longer) was defined as having met the criterion for successful germination. After the germination count was conducted, the seeds were discarded.

After each of the germination counts from both the Warm and the Cool Germination Tests was performed and recorded, mathematical totals of both fifty seed replications were obtained from the two test results. These numbers were added together and used to compute the CWVI score. This score is calculated by combining the percentages of both the Cool Germination Test and the four-day Warm Germination Test data. The resulting number was compared to the following rankings. The rankings include Poor = less than 120, Fair = 120 to 139, Good = 140 to 159, or Excellent = 160 and higher. The results of the seed ranking can be beneficial to seed companies and growers alike because this ranking demonstrates the vigor and the viability of the seed in question.

Data from this study were analyzed as replication-treatment and factorial analysis of variance models using the GLM and MIXED procedures developed by the SAS Institute Inc. of Cary, North Carolina. All field experiments were analyzed according to each site's location and the year of the testing, as well as to the types of treatments that were performed at each site.

All experiments were designed as randomized complete block with four replications; the treatments were included in the rep-treatment model to determine the effects of all six harvest aid chemical treatments on seed quality, as compared to the seed quality of the untreated control, left to the freeze, and to the control treated only with paraquat. Mean separations were determined using Fisher's protected F-test method.

CHAPTER IV

RESULTS AND DISCUSSION

The 1997 and 1998 growing seasons (May through August), at all locations, had a combined average that exceeded the approximately 1093 heat units required to mature cotton (heat units calculated as (high + low) /2 – 15.5^{o} C base temperature). By the end of the growing season (August), the heat units for the 1997 year ranged from approximately 1260 heat units for the southern location (Lamesa) to approximately 1038 heat units for the northern location (Lubbock). The 1998 season accumulations were even greater with approximately 1371 heat units at the southern location (Seminole) and 1149 heat units at the northern location (Olton) recorded by the end of the growing season. The 1997 and 1998 fall seasons, at all locations, were dry and warm; these environmental conditions caused the cotton to be more responsive to the harvest aid chemical applications than would have typically occurred in years when cooler and wetter conditions existed.

LAMESA 1997

Cool-Warm Vigor Index

Each cotton plant, that had bolls harvested from it, was divided into three sections. The upper one-third section was designated as Stratum 1. The middle one-third of the plant was designated as Stratum 2, and the lower one-third of the plant was designated as Stratum 3. The general linear model, analysis of variance of CWVI data for the strata sampling from the 1997 Lamesa location indicated a significant difference between Stratum 1, with a CWVI of 116, and the CWVI values of Strata 2 and 3, which were 147 and 150, respectively (Table 4.1). This indicated that the seed produced in the upper portion of the plants was somewhat of a lower quality than the seed produced in the lower two-thirds of the plants.

The analysis of variance did not indicate a difference among any of the treatments in Stratum 1 (Appendix A.1). Although it is intuitive that differences should exist, none were found (Table 4.1). This is perhaps due to experimental variability. The analysis of variance did indicate significant differences for CWVI in Stratum 2 (Appendix A.2). Mainly, these differences existed among the paraquat check and the dimethipin application (low rate), at both 10 and 30% open bolls, and the high rate at 30% open boll. The reasons for the differences are unclear (Table 4.1). No differences were observed for any treatments in Stratum 3 (Appendix A.3) for CWVI (Table 4.1).

Table 4.1. 1997 Lamesa rep-treatment analyses of Cool Warm Vigor Index by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	114a[2/]	136bc	152a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	117a	156a	146a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	120a	162a	153a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	123a	153ab	148a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	103a	145abc	152a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	115a	146abc	148a
7) Untreated control	130a	148abc	162a
8) Paraquat control	106a	133c	143a
Average	116 A[1/]	147 B	150 B

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test).

When analyzed using the Mixed Procedure, the overall CWVI average across the three strata for the treatments indicated no significant differences, except between the untreated check and the paraquat control (Table 4.2). Differences could be attributed to the fact that the untreated check was allowed to gain somewhat more maturity in the field compared to the paraquat control (Appendix A.4). One would assume that the same hypothesis would have applied to the other treatments; however, they were not significantly different when compared to the untreated check.

Table 4.2. 1997 Lamesa Cool Warm Vigor Index means averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	average
10% OB	134	145	133	137 m[2]	146 s[3]	127 t	137 A
30% OB	140	141	136	138 m			
average	137 a[1]	143 a	135 a	138 A[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Seed Index

Analysis of seed index data indicated significant differences among the strata. The Stratum 1 mean (8.7) was lower than the other two strata. Stratum 2 (10.2) was lower than Stratum 3 (11.1) for seed index (Table 4.3). This suggested that the seed produced in the upper one-third of the plants was of lower weight than those produced lower in the plant.

The analysis of variance for Stratum 1 indicated that significant differences were noted among treatments (Appendix A.5). The ethephon plus tribufos, applied at both 10% and 30% open bolls, significantly reduced seed index when compared to the untreated check. The seed index for the untreated check was also greater than the dimethepin at the high rate, applied at 30% open boll. Reasons for the differences were unclear. One would assume that the earlier 10% open boll application of this chemical treatment would have been more likely to reduce seed index. The paraquat control also resulted in a higher seed index than the ethephon plus tribufos, when applied at 10% open boll. This was due to the nature of the activity of this treatment combination. No significant differences were noted among treatments in Stratum 2 (Appendix A.6) and Stratum 3 (Appendix A.7).

Table 4.3. 1997 Lamesa rep-treatment analyses of seed index (g/100 seed) by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	8.7abc[2/]	10.2a	11.0a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	8.7bc	10.3a	11.1a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	9.0ab	10.3a	11.0a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	9.1ab	10.2a	11.3a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	7.06d	9.8a	11.0a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	8.3cd	10.2a	10.9a
7) Untreated check	9.4a	10.7a	11.1a
8) Paraquat control	8.8abc	10.2a	11.1a
Average	8.7 A[1/]	10.2 B	11.1 C

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test).

When analyzed using the Mixed Procedure, the overall seed index average across the three strata for the treatments, indicated significant differences (Table 4.4). The main effect of application timing was significant; however, there were no differences noted among chemical effects (Appendix A.8). Even though the magnitude of the application timing difference had significance, it was small and unimportant. Differences were noted for the untreated check compared to the paraquat check. As stated earlier, the untreated check may have been affected due to additional maturity time. The average of the chemical treatments, applied at both 10% and 30% open bolls, was lower than both check treatments, thus indicating that the average seed index was reduced by chemical applications.

Table 4.4. 1997 Lamesa seed index means (g/100seed) averaged across three strata.

	Chemical				Control		
timing[9]	Dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	average
10% OB	10.0	10.2	9.5	9.9 n[2]	10.4 s[3]	10.0 t	10.2 A
30% OB	10.0	10.2	9.8	10.0 o			
averae	10.0 a[1]	10.2 b	9.6 c	9.9 B[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Yield and Micronaire

The analysis of variance for yield indicated that no significant differences were noted among treatments at the 0.05 probability level (Table 4.5). These treatments were significant, however, at the 0.10 probability level. In general, the dimethipin treatments tended to have somewhat higher lint yield than the untreated check, but did not differ from the paraquat control (Appendix A.9). There was also a trend to have reduced yield with the ethephon plus tribufos treatments, applied at both 10% and 30% open bolls. No statistically significant effects on micronaire were noted at this site (Appendix A.10).

Table 4.5. Rep-treatment analyses of yield and micronaire for 1997 Lamesa location.

Treatment	Yield Lint kg ha^{-1}	Micronaire
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	894 a	3.8 a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	884 a	3.9 a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	855 a	3.8 a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	729 a	3.9 a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10% OB	730 a	3.5 a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30% OB	793 a	3.8 a
7) Untreated Check	764 a	3.9 a
8) Paraquat control	799 a	3.9 a
LSD[1]	NS	NS
OSL[2]	0.0545	0.3888

[1]LSD - least significant difference at the 0.05 level.

[2]OSL - observed significance level.

NS - not significant level.

Means within the same column followed by the same letter not significantly different.

LUBBOCK 1997

Cool-Warm Vigor Index

The analysis of variance of CWVI data for the strata sampling from the 1997 Lubbock location indicated a significant difference between Stratum 1, with a CWVI of 125, and the CWVI values of Strata 2 and 3, which were 159 and 166, respectively (Table 4.6). The upper one-third of the plant was of lower quality than the lower two-thirds of the plants.

The analysis of variance did not indicate a difference among any of the treatments in Stratum 1 (Appendix A.11). As at Lamesa in 1997, although it was intuitive that differences should exist, none were found; perhaps this was due to experimental variability. The analysis of variance did indicate significant differences for CWVI in Stratum 2 (Appendix A.12). However, these differences were not easily explained since the ethephon plus tribufos, at both application timings, and the dimethipin low rate, applied at 30% open boll, all tended to have somewhat higher CWVI values than both the untreated check and the paraquat control. The reasons for this anomaly were unclear. No differences were observed for any treatments in Stratum 3 for CWVI (Appendix A.13).

Table 4.6. 1997 Lubbock rep-treatment analyses of Cool Warm Vigor Index by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	113b[2/]	154b	152a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	132ab	154b	175a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	114b	161ab	169a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	138a	168a	167a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	122ab	169a	163a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	130ab	160ab	163a
7) Untreated check	116ab	150b	167a
8) Paraquat control	132ab	155b	170a
Average	125 A[1/]	159 B	166 C

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test).

The overall CWVI average across the three strata for the treatments indicated significant differences (Table 4.7), when analyzed using the Mixed Procedure. The application timing, main effect mean separation indicated that the 30% open boll application timing resulted in overall higher CWVI values than the 10% open boll application timing (Appendix A.14). This was due to the overall impact of the premature harvest aid application on the 10% open boll, which produced average seed quality.

Table 4.7. 1997 Lubbock Cool Warm Vigor Index means averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	Utc[6]	par_con[5]	average
10% OB	139	148	152	146 m[2]	144 s[3]	152 s	148 A
30% OB	154	158	151	154 n			
average	147 a[1]	153 a	152 a	150 A[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical applications at 0.51 kg ai ha^{-1} rate.

Seed Index

Analysis of seed index data indicated significant differences among the strata. The Stratum 1 mean (7.9) was lower than the other two strata. Stratum 2 (9.7) and Stratum 3 (10.1) were similar for seed index (Table 4.8). The analysis of variance for Stratum 1 indicated significant differences were noted among treatments (Appendix A.15). No difference was observed between the untreated check and the paraquat control. When compared to the untreated check and the paraquat control, the ethephon plus tribufos, at both 10% and 30% open bolls, reduced seed index. Additionally, the 10% open boll application of both rates of dimethipin reduced seed index when compared to both the untreated check and the paraquat control. This indicated that premature harvest aid application, at this site, significantly reduced seed quality in Stratum 1. No significant differences among treatments were noted in Stratum 2 (Appendix A.16) and Stratum 3 (Appendix A.17), indicating that the premature harvest aid application had no effect on seed in the bottom two-thirds of the plants sampled.

Table 4.8. 1997 Lubbock rep-treatment analyses of seed index (grams/100 seed) by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	6.7e[2/]	9.6a	9.9a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	8.5ab	9.9a	10.1a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	7.6cd	9.5a	10.1a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	8.4ab	9.4a	10.0a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	7.1de	9.4a	10.3a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	8.0bc	9.7a	10.1a
7) Untreated check	8.6a	9.9a	10.3a
8) Paraquat control	8.5ab	9.7a	10.2a
Average	7.9 A[1/]	9.7 B	10.1 B

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test.

When analyzed using the Mixed Procedure, the overall seed index average across the three strata for the treatments indicated significant differences (Table 4.9). The application timing, main effect mean separation, noted that the 30% open boll application timing resulted in overall higher seed index values than the 10% open boll application timing (Appendix A.18). This was attributed to the overall impact of the premature harvest aid application, which reduced seed index and quality. This same effect was noted for CWVI at this site.

Table 4.9. 1997 Lubbock seed index means (grams/100seed) averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	average
10% OB	8.8	9.1	9.0	8.9 n[2]	9.6 s[3]	9.5 s	9.5 A
30% OB	9.5	9.3	9.3	9.3 m			
average	9.1 a[1]	9.2 a	9.1 a	9.1 B[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Yield and Micronaire

The analysis of variance for both yield and micronaire indicated significant differences among treatments (Table 4.10). No differences were observed between the untreated check and the paraquat control for both yield (Appendix A.19) and micronaire (Appendix A.20). However, when compared to both the untreated check and the paraquat control, the ethephon plus tribufos, at both 10% and 30% open bolls, reduced both yield and micronaire. Additionally, the 10% open boll application of both rates of dimethipin reduced yield and micronaire, compared to both the untreated check and the paraquat control. Furthermore, the premature harvest aid application effects associated with reduced CWVI and seed index sometimes negatively impacted both yield and micronaire.

Table 4.10. Rep-treatment analyses of yield and micronaire for 1997 Lubbock location.

Treatment	Yield Lint Kg ha^{-1}	Micronaire
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	877 D	4.0 C
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	982 ABC	4.5 A
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	905 CD	4.2 B
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	973 ABC	4.4 A
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	894 CD	4.0 C
6) Ethephon plus Tribuos 0.84 kg ai ha^{-1} at 30%OB	918 BCD	4.2 B
7) Untreated Check	1053 A	4.4 A
8) Paraquat control	1004 AB	4.4 A
LSD[1]	94	0.165
OSL[2]	0.009	<0.0001

[1]LSD - least significant difference at the 0.05 level.

[2]OSL - observed significance level.

Means within the same column followed by the same letter not significantly different.

LUBBOCK 1998

Cool Warm Vigor Index

The analysis of variance of CWVI data for the strata sampling, from the 1998 Lubbock location, indicated a significant difference between Stratum 1, with a CWVI of 103, and the CWVI values of Strata 2 and 3, which were not different at 131 and 128, respectively (Table 4.11). The analysis of variance did not indicate a difference among any of the treatments in Stratum 1 (Appendix A.21). Again, as at Lamesa in 1997, although it was intuitive that differences should exist, none were found; perhaps this was due to experimental variability, environmental conditions, or the condition of the cotton at harvest aid application. The 1998 growing season was very hot and dry compared to 1997. Seed maturity may have been more advanced than expected, even at the 10% and 30% open bolls. The analysis of variance also did not indicate significant differences for CWVI in Stratum 2 (Appendix A. 22) or in Stratum 3 (Appendix A.23).

When averaged across the three strata for the treatments and when analyzed using the Mixed Procedure, the overall CWVI indicated that no significant differences (Appendix A.24) were found (Table 4.12).

Table 4.11. 1998 Lubbock rep-treatment analyses of CWVI by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	109a[2/]	134a	125a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	98a	124a	131a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	98a	146a	128a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	102a	123a	123a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	107a	139a	132a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	100a	129a	131a
7) Untreated check	104a	131a	132a
8) Paraquat control	109a	131a	126a
Average	103 A[1/]	131 B	128 B

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test.

Table 4.12. 1998 Lubbock CWVI means averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[6]	average	utc[6]	par_con[5]	average
10% OB	122	124	126	124 m[2]	122 s[3]	122 s	122 A
30% OB	118	116	120	118 m			
average	120 a[1]	120 a	123 a	121 A[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraqua control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Seed Index

Analysis of seed index data indicated significant differences among the strata. The Stratum 1 mean (8.1) was lower than the other two strata. Stratum 2 (9.8) and Stratum 3 (10.0) were similar for seed index (Table 4.13). No significant differences were noted among any treatments for Stratum 1 (Appendix A. 25), Stratum 2 (Appendix A.26), or Stratum 3 (Appendix A.27). At this site, neither CWVI nor seed index differences were observed. Reasons for these differences were unclear, based on the effects of harvest aid treatments found for both yield and micronaire (see below).

When analyzed using the Mixed Procedure, the overall seed index average across the three strata for the treatments (Appendix A.28) indicated significant differences (Table 4.14). This would likely be attributed to the fact that no differences were noted for seed index for Strata 1, 2 or 3.

Table 4.13. 1998 Lubbock rep-treatment analyses of seed index (g/100seed) by statum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	8.4a[2/]	10.0a	10.1a
2) Dimethipin 0.51 kg ai ha^{1} at 30% OB	8.1a	9.9a	10.2a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	8.0a	9.9a	10.1a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	8.3a	9.7a	10.1a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	7.8a	9.7a	9.8a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	7.7 a	9.7a	9.9a
7) Untreated check	8.2a	9.6a	10.1a
8) Paraquat control	8.4a	9.9a	10.1a
Average	8.1 A[1/]	9.8B	10B

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test.

Table 4.14. 1998 Lubbock seed index means (g/100 seed) averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	Average
10% OB	9.5	9.3	9.1	9.3 m[2]	10.4 s	10.0 s[3]	10.2 A
30% OB	9.4	9.3	9.1	9.3 m			
average	9.4 a[1]	9.3 a	9.1 a	9.3 A[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/]Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Yield and Micronaire

The analysis of variance for yield indicated significant differences among treatments (Table 4.15). No yield differences were observed between the untreated check and the paraquat control. However, when compared to the paraquat control, the ethephon plus tribufos applications, at both 10% and 30% open bolls, reduced yield (Appendix A.29). Additionally, the 10% open boll application of both rates of dimethipin reduced yield, compared to the paraquat control. The 30% open boll application of dimethipin, at the low rate, reduced yield compared to the paraquat control. The 30% open boll application of dimethipin, at the high rate, did not reduce yield. Reasons for this difference were unclear.

The analysis of variance for micronaire indicated significant differences among treatments (Table 4.15). No differences were observed between the untreated check and the paraquat control for micronaire. The ethephon plus tribufos, applied at both 10% and 30% open bolls, severely reduced micronaire. The high dimethipin rate, applied at 10% and 30% open bolls, did not significantly reduce micronaire compared to both controls (Appendix A.30). This suggested that the more aggressive physiological activity of the ethephon plus tribufos had a greater negative impact on maturity than the less stringent dimethipin, at this site. Variability in laboratory procedures may have been an issue, at this site, since some premature harvest aid applications had no effects on CWVI and seed index, yet yield and micronaire were reduced.

Table 4.15. Rep-treatment analyses of yield and micronaire for Lubbock 1998 location.

Treatment	Yield Lint Kg ha^{-1}	Micronaire
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	582 bc	4.5 abc
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	618 ab	4.4 abc
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	591 bc	4.3 bcd
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	571 bc	4.2 cd
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	525 c	3.9 e
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	542 bc	4.0 de
7) Untreated Check	625 ab	4.6 a
8) Paraquat control	683 a	4.5 ab
LSD[1]	90	0.3
OSL[2]	0.0372	0.0005

[1]LSD - least significant difference at the 0.05 level.

[2]OSL - observed significance level.

Means within the same column followed by the same letter not significantly different.

OLTON 1998

Cool Warm Vigor Index

Moderate to high lint yield and low micronaire, indicators of poor fiber and seed maturity, were encountered at this site. The analysis of variance of CWVI data for the strata sampling, from the 1998 Olton location, indicated a significant difference between Stratum 1, with a CWVI of 117, and the CWVI values of Strata 2 and 3, which were not different, at 152 and 158, respectively (Table 4.16). These comparisons indicated that seed produced in the upper one-third of the plant was typically lower in quality than the seed in the lower two-thirds of the plant.

The analysis of variance indicated a difference in CWVI between the treatments in Stratum 1 (Appendix A.31). A significant difference was observed between the untreated check (115) and the paraquat control (152). This difference was likely due to field weathering of the untreated check, which was left to the freeze and harvested somewhat later than the paraquat control. Normally, the untreated check would be expected to have the highest CWVI because of the additional maturity time. The CWVI for the paraquat control was higher than those for all application timings of all chemicals, except for the low rate of dimethipin applied at 30% open boll. Even this treatment was substantially numerically lower. The analysis of variance did not indicate significant differences for CWVI in Stratum 2 (Appendix A. 32) or in Stratum 3 (Appendix A.33). When averaged across the three strata for the treatments and when analyzed using the Mixed Procedure, the overall CWVI (Appendix A.34) indicated that no significant differences were found (Table 4.17).

Table 4.16. 1998 Olton rep-treatment analyses of CWVI by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	96c[2/]	139a	166a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	114bc	139a	143a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	112bc	160a	163a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	129ab	155a	162a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10% OB	102bc	155a	155a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30% OB	115bc	154a	148a
7) Untreated check	115bc	150a	161a
8) Paraquat control	152a	164a	163a
Average	117 A[1/]	152 B	158 B

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test).

Table 4.17. 1998 Olton CWVI means averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	Average
10% OB	134	145	137	139 m[2]	142 s[3]	160 s	151 A
30% OB	132	149	139	140 m			
average	133 a[1]	147 a	138 a	139 A[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at Same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Seed Index

Analysis of seed index data indicated significant differences among the strata. The Stratum 1 mean (10.5) was lower than the other two strata. Stratum 2 (12.0) was lower than Stratum 3 (12.6) (Table 4.18). The seed produced in the upper one-third of the plant was of lower weight than the seed produced by the lower two-thirds of the plant.

The analysis of variance for Stratum 1 (Appendix A. 35) indicated significant differences were noted among treatments. No difference was observed between the untreated check and the paraquat control. For reasons mentioned above, further comparisons will only be made with the paraquat control. When compared to the paraquat control, the ethephon plus tribufos at 10% open boll reduced seed index. Additionally, the 10% open boll application at the high rate of dimethipin reduced seed index, compared to the paraquat control. This indicated that some premature harvest aid applications, at this site, significantly reduced seed weight in Stratum 1. No significant differences among treatments were noted in Stratum 2 (Appendix A. 36) or Stratum 3 (Appendix A. 37). This indicated that the premature harvest aid application had no effect on seed in the bottom two-thirds of the plants sampled. When analyzed using the Mixed Procedure, the overall seed index average across the three strata for the treatments (Appendix A. 38) indicated only minor differences between average of control and chemical (Table 4.19), thus being of minimal importance.

Table 4.18. 1998 Olton rep-treatment analyses of seed index (g/100seed) by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	10.0bc[2/]	11.8a	12.7a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	10.7ab	12.2a	12.6a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	10.4ab	12.1a	12.5a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	10.9a	11.9a	12.2a
5) Ethephon & Tribufos 0.84 kg ai ha^{-1} at 10% OB	9.6c	11.9a	12.5a
6) Ethephon & Tribufos 0.84 kg ai ha^{-1} at 30% OB	10.5ab	11.9a	12.3a
7) Untreated check	10.7ab	12.1a	12.9a
8) Paraquat control	11.0a	12.2a	12.9a
Average	10.5 A[1/]	12.0 B	12.6 C

[1/] Stratum means averaged over treatments followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test.

Table 4.19. 1998 Olton seed index means (g/100seed) averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	average
10% OB	11.5	11.7	11.3	11.5 m[2]	11.9 s[3]	12.0 s	11.9 A
30% OB	11.8	11.7	11.5	11.6 m			
average	11.7 a[1]	11.7 a	11.4 a	11.6 B[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/]Paraquat control treatments had an application made to terminate the treatments at same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Yield and Micronaire

The analysis of variance for yield (Appendix A.39) indicated no significant differences among treatments for yield (Table 4.20). As mentioned above, this site exhibited moderate to high lint yield, with consistently low micronaire (Table 4.20) across all treatments, including both controls. Due to its overall unique situation (further north and a somewhat higher elevation), as compared to other sites used in this project, the Olton site has generally been known to produce cotton that exhibits a lower micronaire than that produced at the other locations (Appendix A.40). The cultivar planted at this site was Paymaster 145, the most determinate of all those planted in the project across the five sites. This may account for the lack of yield and micronaire responses among treatments.

Table 4.20. Rep-treatment analyses of yield and micronaire for 1998 Olton location.

Treatment	Yield Lint Kg ha^{-1}	Micronaire
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	903 a	2.6 a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	867 a	2.7 a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	890 a	2.7 a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	1009 a	2.8 a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	943 a	2.8 a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	843 a	2.8 a
7) Untreated Check	923 a	2.7 a
8) Paraquat control	959 a	2.8 a
LSD[1]	NS	NS
OSL[2]	0.1834	0.2946

[1]LSD - least significant difference at the 0.05 level.

[2]OSL - observed significance level.

NS - not significant level.

Means within the same column followed by the same letter not significantly different.

SEMINOLE 1998

Cool-Warm Vigor Index

The analysis of variance of CWVI data for the strata sampling, from the 1998 Seminole location, indicated a significant difference between Stratum 1, with a CWVI of 94, and the CWVI values of Strata 2 and 3, which were different at 149 and 173, respectively (Table 4.21). The analysis of variance did indicate a difference in CWVI among treatments in Stratum 1 (Appendix A.41). A significant difference was observed between the untreated check, left to the freeze, (147) and the paraquat control (80). This difference was likely due to a wind storm that caused preharvest losses of some of the more immature cotton from the open-boll, picker type cultivar planted (Deltapine 5415). Some 200 kg ha^{-1} of lint was lost, preharvest, at this site. The other treatments were harvested in a timelier manner and were not exposed to the windstorm losses. The only differences observed were between the untreated control and all application timings and chemicals. No differences were noted for the paraquat control that was harvested at the same time as the other treatments. The analysis of variance did not indicate significant differences among treatments for CWVI in Stratum 2 (Appendix A. 42) or in Stratum 3 (Appendix A.43).

Table 4.21. 1998 Seminole rep-treatment analyses of Cool Warm Vigor Index by stratum.

	STRATA		
Treatment	Stratum 1	Stratum 2	Stratum 3
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	78c[2/]	159a	179a
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	94bc	151a	175a
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	84bc	152a	174a
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	78c	146a	168a
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	83bc	148a	172a
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	104b	134a	175a
7) Untreated check	147a	157a	174a
8) Paraquat control	80bc	142a	169a
Average	94A[1/]	149B	173C

[1/] Stratum means averaged over treatments followed by the same upper case letter are not significantly different ($p>0.05$, protected LSD test).

[2/] Mean within a stratum followed by the same lower case letter are not significantly different ($p>0.05$, protected LSD test

When averaged across the three strata for the treatments and when analyzed using the Mixed Procedure, the overall CWVI indicated significant differences between the untreated control and the other treatments (Table 4.22). According to the analysis of variance (Appendix A.44), there were significant differences between the untreated check and the paraquat control. The differences between the two reflect the additional maturity time received by the untreated check.

Table 4.22. 1998 Seminole CWVI means averaged across three strata.

	Chemical				Control		
timing[9]	dim_0.51[10]	dim_0.34[8]	e_t_0.84[7]	average	utc[6]	par_con[5]	average
10% OB	139	137	135	137 m^2	159 s^3	130 t	145 A
30% OB	140	130	138	136 m			
average	140 a[1]	134 a	137 a	137 B[4]			

[1/] Chemical means averaged over timing followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[2/] Timing means averaged over chemicals followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[3/] Control means followed by the same lower case letter are not significantly different (P>0.05, protected LSD test).

[4/] Chemical and control (average) means followed by the same upper case letter are not significantly different (P>0.05, protected LSD test).

[5/] Paraquat control treatments had an application made to terminate the treatments at Same time as the chemical and timing treatments were terminated.

[6/] Untreated check treatments were terminated by freeze.

[7/] Ethephon and Tribufos chemical application at 0.84 kg ai ha^{-1} rate.

[8/] Dimethipin chemical application at 0.34 kg ai ha^{-1} rate.

[9/] Timing of application at either 10% or 30% open boll.

[10/] Dimethipin chemical application at 0.51 kg ai ha^{-1} rate.

Seed Index Values

Due to the fact that the samples were accidentally discarded in the laboratory, no seed index data for the Seminole 1998 location were available.

Yield and Micronaire

The analysis of variance for yield indicated significant differences among treatments (Table 4.23). Yield differences were observed between the untreated check and the paraquat control. Due to the storm effect on the untreated control, the best treatment comparisons, at this site, can be made using the paraquat control. The untreated check was lower in yield than all other treatments, except the ethephon plus tribufos applications at 10% and 30% open bolls (Appendix A. 45). The paraquat control had significantly greater yield than both the ethephon plus tribufos applications, at 10% and 30% open bolls. The dimethipin treatments, at both 10% and 30% open bolls, were not statistically different from the paraquat control. This indicated that the more aggressive physiological activity of the ethephon plus tribufos, in terms of boll opening and defoliation, resulted in greater negative impact on yield than the less stringent dimethipin, at this site.

The analysis of variance for micronaire indicated that significant differences were noted among treatments (Table 4.23). Differences were observed between the untreated check and the paraquat control for micronaire. These differences were thought to be a result of preharvest losses. Treatments that severely reduced micronaire, compared to the paraquat check, included the ethephon plus tribufos applied at both 10% and 30% open bolls (Appendix A.46). Treatments of both the low and high dimethipin rates, applied at 10% open boll, and the high rate of dimithipin, applied at 30% open boll, reduced micronaire when compared to the paraquat check; however, the magnitude was not as great as with the ethephon plus tribufos treatments.

Table 4.23. Rep-treatment analyses of yield and micronaire for 1998 Seminole location.

Treatment	Yield Lint Kg ha^{-1}	Micronaire
1) Dimethipin 0.51 kg ai ha^{-1} at 10% OB	1039 ab	3.2 bc
2) Dimethipin 0.51 kg ai ha^{-1} at 30% OB	1103 a	3.2 bc
3) Dimethipin 0.34 kg ai ha^{-1} at 10% OB	1053 ab	3.2 bc
4) Dimethipin 0.34 kg ai ha^{-1} at 30% OB	1049 ab	3.3 ab
5) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 10%OB	876 bc	3.0 c
6) Ethephon plus Tribufos 0.84 kg ai ha^{-1} at 30%OB	909 bc	3.1 c
7) Untreated Check	748 c	3.2 bc
8) Paraquat control	972 ab	3.5 a
LSD[1]	190	0.2478
OSL[2]	0.0149	0.0234

[1]LSD - least significant difference at the 0.05 level

[2]OSL - observed significance level

Means within the same column followed by the same letter not significantly different.

CHAPTER V

SUMMARY AND CONCLUSIONS

The 1997 and 1998 environments presented almost ideal growing conditions for irrigated cotton crops at all locations, if adequate irrigation capacity was available. The initial hypothesis of this study was that there would be significant differences achieved in cottonseed quality as a result of using various harvest aid chemicals, including dimethipin and ethephon plus tribufos, with application timings at either 10% or 30% open boll. The environmental differences encountered between the northern locations, of Olton and Lubbock, and the southern locations, of Lamesa and Seminole, produced somewhat varying results for some of the measured parameters.

Utilizing three harvest aid chemicals and two application timings over a two year period at five sites, testing results and the harvested seeds' vigor were determined utilizing the CWVI and seed index. Additionally, lint yield and micronaire were measured. The two types of controls utilized were an untreated check, left to the freeze, and a paraquat control. The untreated check was not necessarily the best method to use for chemical effect comparisons, possibly due to maturity and preharvest loss issues. Therefore, the paraquat control generally produced more consistent results for comparing with other chemical treatment effects.

In general, stratified sampling results indicated that CWVI and seed index were adversely affected by harvest aid chemicals at the two timings of application. Two of the

five sites exhibited substantial, negative effects in Stratum 1 due to applications of ethephon plus tribufos and dimethipin at 10% and 30% open bolls. At two of the five sites, similar effects in Stratum 2 were noted when these same chemicals and application timings were used. It is unclear why both of these sites exhibited seed quality losses in Stratum 2, yet they were not observed in Stratum 1. No statistically significant effects on CWVI were observed at any site in Stratum 3. This indicated that the seed was apparently mature enough to be unaffected by chemicals and application timings. When averaged across the three strata for the treatments and when analyzed using the Mixed Procedure, the overall CWVI indicated that significant differences were found only at two of the five locations. These differences resulted from issues arising from the untreated, left to the freeze check when compared to the other treatments, particularly the paraquat check.

As a result of the chemical applications at three of the four locations, the seed index for Stratum 1 was noted to have significant differences. One site had no observations for seed index. Depending upon location, Stratum 1 effects were mostly dominated by the extremely aggressive physiological response to ethephon plus tribufos, applied at either 10 or 30% open boll. With these application timings, it is obvious that ethephon plus tribufos significantly reduces seed index when compared to the paraquat check. Generally speaking, the dimethipin rates and treatments were not as detrimental to seed index as was the ethephon plus tribufos. No statistically significant effects on seed index were observed at any site in Strata 2 or 3. When averaged across the three strata for the treatments and when analyzed using the Mixed Procedure, the overall seed

index indicated that significant differences were typically not detected at the five locations. Some of the observed differences were a direct result of the untreated, left to the freeze check. Perhaps averaging across strata was not necessarily an appropriate method to detect potential differences. This method may be ineffective because it only takes into account the average for the individual stratified sampling results, and it is not weighted based on distribution of yield for each of the three zones sampled.

Lint yield results indicated that significant differences were noted at four of the five locations. When compared to the paraquat control, ethephon plus tribufos applied at both 10% and 30% open bolls significantly reduced lint yield at three of the five locations. Also, when compared to the paraquat control, dimethipin at low rates, at both 10% and 30% open bolls, resulted in significantly lower yield at two of the five locations. Dimethipin at the high rate, applied at 10% open boll, reduced yield when compared to the paraquat check at two of the five locations. Again, it is evident that the more aggressive ethephon plus tribufos treatment can significantly reduce lint yield if applied at 30% open boll or less. Likewise, even the less stringent dimethipin defoliant can also reduce yield under certain conditions.

Micronaire was reduced at three of the five locations by ethephon plus tribufos, applied at 10% and 30% open bolls, when compared to the paraquat check. Two locations of the five exhibited significant micronaire reductions when both rates of dimethipin were applied at 10% open boll. Only one location of five exhibited a micronaire reduction from the low rate of dimethipin, at a 30% open boll application, when compared to the paraquat check. Since micronaire generally translates into lint

yield, it is very apparent that the early applications of ethephon plus tribufos can adversely affect profitability. At times, the same is true of dimethipin. significant

To summarize, the results from this research did indicate that reductions in seed quality (CWVI and seed index) can be caused by premature applications of certain harvests aid chemicals. There was no indication that the use of any of the chemicals or the timing of their application caused the enhanced movement of photosynthates into the seed which might result in a benefit of higher vigor or weight. In fact, quite the opposite was noted.

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APPENDIX

ANALYSES OF VARIANCE

A.1

Analysis of variance summary of variables for Lamesa 1997 location for Cool Warm Vigor Index strata.

Stratum 1

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	6009.06250	600.90625	2.03	0.0826
Error	21	6218.40625	296.11458		
Corrected Total	31	12227.46875			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.491440	14.93505	17.20798	115.2188

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	3909.343750	1303.114583	4.40	0.0149
trt	7	2099.718750	299.959821	1.01	0.4504

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	3909.343750	1303.114583	4.40	0.0149
trt	7	2099.718750	299.959821	1.01	0.4504

A.2

Analysis of variance of variables for Lamesa 1997 location for Cool Warm Vigor Index strata.

Stratum 2

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	8678.50000	867.85000	5.83	0.0003*
Error	21	3125.50000	148.83333		
Corrected Total	31	11804.00000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.735217	8.285044	12.19973	147.2500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	5981.000000	1993.666667	13.40	<.0001
trt	7	2697.500000	385.357143	2.59	0.0431

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	5981.000000	1993.666667	13.40	<.0001
trt	7	2697.500000	385.357143	2.59	0.0431

A.3

Analysis of variance of variables for Lamesa 1997 location for Cool Warm Vigor Index strata.

Stratum 3

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	4143.500000	414.350000	2.14	0.0680
Error	21	4062.000000	193.428571		
Corrected Total	31	8205.500000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.504966	9.248785	13.90786	150.3750

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	3121.000000	1040.333333	5.38	0.0066
trt	7	1022.500000	146.071429	0.76	0.6298

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	3121.000000	1040.333333	5.38	0.0066
trt	7	1022.500000	146.071429	0.76	0.6298

Analysis of variance summary of individual variables and interactions for Lamesa 1997 location for Cool Warm Vigor Index.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	1.68	0.1671ns
Strata	2	48	74.27	<.0001*
Treatments x Strata	4	48	1.02	0.4463ns

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	1.54	0.2385ns
Timing	1	21	0.16	0.6930ns
Chemical x Timing	2	21	0.51	0.6087ns
Untreated = Untreated Paraquat	1	21	7.43	0.0126*
Control vs Treatments	1	21	0.11	0.7403ns
Untreated vs Treatments	1	21	2.34	0.1407ns
Untreated Paraquat = Treatments	1	21	4.16	0.0543ns
Chemical x Strata	4	48	0.72	0.5797ns
Timing x Strata	2	48	1.36	0.2661ns
Chemical x Timing x Strata	4	48	1.68	0.1697ns

* Significant at the 0.05 level of probability.

A.5

Analysis of variance of variables for Lamesa 1997 location for seed index values strata.

Stratum 1

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	9.06022500	0.90602250	3.89	0.0042*
Error	21	4.89257500	0.23297976		
Corrected Total	31	13.95280000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.649348	5.505330	0.482680	8.767500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.18652500	0.06217500	0.27	0.8485
trt	7	8.87370000	1.26767143	5.44	0.0011

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.18652500	0.06217500	0.27	0.8485
trt	7	8.87370000	1.26767143	5.44	0.0011

A.6

Analysis of variance of variables for Lamesa 1997 location for seed index value strata.

Stratum 2

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	3.32367500	0.33236750	3.11	0.0137*
Error	21	2.24547500	0.10692738		
Corrected Total	31	5.56915000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.596801	3.183620	0.326998	10.27125

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1.57062500	0.52354167	4.90	0.0098
trt	7	1.75305000	0.25043571	2.34	0.0620

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1.57062500	0.52354167	4.90	0.0098
trt	7	1.75305000	0.25043571	2.34	0.062

A.7

Analysis of variance of variables for Lamesa 1997 location for seed index value strata.

Stratum 3

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.56735000	0.05673500	0.44	0.9079
Error	21	2.69160000	0.12817143		
Corrected Total	31	3.25895000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.174090	3.218432	0.358010	11.12375

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.27545000	0.09181667	0.72	0.5532
trt	7	0.29190000	0.04170000	0.33	0.9338

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.27545000	0.09181667	0.72	0.5532
trt	7	0.29190000	0.04170000	0.33	0.9338

Analysis of variance of individual variables for Lamesa 1997 location for seed index values.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	5.09	0.0017*
Strata	2	48	339.69	<.0001*
Treatments x Strata	14	48	5.37	<.0001*

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	0.04	0.9644ns
Timing	1	21	15.77	0.0007*
Chemical x Timing	2	21	2.45	0.1104ns
Untreated = Untreated Paraquat	1	21	0.61	0.4438ns
Control vs Treatments	1	21	14.30	0.0011*
Untreated vs Treatments	1	21	11.36	0.0029*
Untreated Paraquat = Treatments	1	21	5.51	0.0288*
Chemical x Strata	4	48	3.33	0.0174*
Timing x Strata	2	48	21.62	<.0001*
Chemical x Timing x Strata	4	48	11.48	<.0001*

* Significant at the 0.05 level of probability.

Analysis of variance of individual variables for Lamesa 1997 location for yield.

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	138291.8125	13829.1813	2.47	0.0391*
Error	21	117792.1563	5609.1503		
Corrected Total	31	256083.9688			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	yield Mean
0.540025	10.40876	74.89426	719.5313

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	42939.09375	14313.03125	2.55	0.0830
trt	7	95352.71875	13621.81696	2.43	0.0545

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	42939.09375	14313.03125	2.55	0.0830
trt	7	95352.71875	13621.81696	2.43	0.0545

Analysis of variance of individual variables for Lamesa 1997 location for micronaire.

Dependent Variable: micronaire

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.57062500	0.05706250	0.84	0.5952ns
Error	21	1.42156250	0.06769345		
Corrected Total	31	1.99218750			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	mic Mean
0.286431	6.730597	0.260180	3.865625

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.04093750	0.01364583	0.20	0.8941
trt	7	0.52968750	0.07566964	1.12	0.3888

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.04093750	0.01364583	0.20	0.8941
trt	7	0.52968750	0.07566964	1.12	0.3888

* Significant at the 0.05 level of probability.

A.11

Analysis of variance of variables for Lubbock 1997 location for Cool Warm Vigor Index strata.

Stratum 1

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	5505.00000	550.50000	2.56	0.0332*
Error	21	4510.87500	214.80357		
Corrected Total	31	10015.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.549627	11.76612	14.65618	124.5625

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	2867.625000	955.875000	4.45	0.0143
trt	7	2637.375000	376.767857	1.75	0.1505

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	2867.625000	955.875000	4.45	0.0143
trt	7	2637.375000	376.767857	1.75	0.1505

A.12

Analysis of variance of variables for Lubbock 1997 location for Cool Warm Vigor Index strata.

Stratum 2

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	3115.062500	311.506250	4.22	0.0026*
Error	21	1551.656250	73.888393		
Corrected Total	31	4666.718750			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.667506	5.409376	8.595836	158.9063

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1754.593750	584.864583	7.92	0.0010
trt	7	1360.468750	194.352679	2.63	0.0406

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1754.593750	584.864583	7.92	0.0010
trt	7	1360.468750	194.352679	2.63	0.0406

A.13

Analysis of variance of variables for Lubbock 1997 location for Cool Warm Vigor Index strata.

Stratum 3

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1967.500000	196.750000	1.61	0.1719
Error	21	2567.375000	122.255952		
Corrected Total	31	4534.875000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.433860	6.668340	11.05694	165.8125

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	635.125000	211.708333	1.73	0.1912
trt	7	1332.375000	190.339286	1.56	0.2030

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	635.125000	211.708333	1.73	0.1912
trt	7	1332.375000	190.339286	1.56	0.2030

Analysis of variance of individual variables and interactions for Lubbock 1997 location for cool warm vigor index.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	2.29	0.0668ns
Strata	2	48	129.99	<.0001*
Treatments*Strata	14	48	1.52	0.1386ns

* Significant at the 0.05 level of probability.

Contrast	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	1.41	0.2663ns
Timing	1	21	6.64	0.0176*
Chemical x Timing	2	21	2.01	0.1586ns
Untreated = Untreated Paraquat	1	21	2.23	0.1505ns
Control vs Treatments	1	21	0.34	0.5688ns
Untreated vs Treatments	1	21	2.00	0.1718ns
Untreated Paraquat = Treatments	1	21	0.29	0.5953ns
Chemical x Strata	4	48	0.60	0.6627ns
Timing x Strata	2	48	4.03	0.0241*
Chemical x Timing x Strata	4	48	2.94	0.0297*

A.15

Analysis of variance of variables for Lubbock 1997 location for seed index values strata.

Stratum 1

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	15.72152500	1.57215250	10.60	<.0001*
Error	21	3.11467500	0.14831786		
Corrected Total	31	18.83620000			

* Significance at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.834644	4.817018	0.385121	7.995000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.09062500	0.03020833	0.20	0.8927
trt	7	15.63090000	2.23298571	15.06	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr >F
rep	3	0.09062500	0.03020833	0.20	0.8927
trt	7	15.63090000	2.23298571	15.06	<.0001

A.16

Analysis of variance of variables for Lubbock 1997 location for seed index values strata.

Stratum 2

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1.97520000	0.19752000	0.84	0.6016
Error	21	4.96648750	0.23649940		
Corrected Total	31	6.94168750			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.284542	5.004819	0.486312	9.716875

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.88441250	0.29480417	1.25	0.3181
trt	7	1.09078750	0.15582679	0.66	0.7036

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.88441250	0.29480417	1.25	0.3181
trt	7	1.09078750	0.15582679	0.66	0.7036

Analysis of variance of variables for Lubbock 1997 location for seed index values strata.

Stratum 3

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1.56358125	0.15635813	2.90	0.0191*
Error	21	1.13219062	0.05391384		
Corrected Total	31	2.69577188			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.580012	2.281790	0.232194	10.17594

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1.18058438	0.39352813	7.30	0.0016
trt	7	0.38299688	0.05471384	1.01	0.4493

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1.18058438	0.39352813	7.30	0.0016
trt	7	0.38299688	0.05471384	1.01	0.4493

Analysis of variance of individual variables for Lubbock 1997 location for seed index values.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	5.09	0.0017*
Strata	2	48	339.69	<.0001*
Treatments x Strata	14	48	5.37	<.0001*

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	0.04	0.9644ns
Timing	1	21	15.77	0.0007*
Chemical x Timing	2	21	2.45	0.1104ns
Untreated = Untreated Paraquat	1	21	0.61	0.4438ns
control vs Treatments	1	21	14.30	0.0011*
Untreated vs Treatments	1	21	11.36	0.0029*
Untreated Paraquat = Treatments	1	21	5.51	0.0288*
Chemical x Strata	4	48	3.33	0.0174*
Timing x Strata	2	48	21.62	<.0001*
Chemical x Timing x Strata	4	48	11.48	<.0001*

* Significant at the 0.05 level of probability.

A.19

Analysis of variance of individual variables for Lubbock 1997 location for yield.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	138715.8125	138710.5813	4.23	0.0026*
Error	21	68802.6563	3276.3170		
Corrected Total	31	207518.4688			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	yield Mean
0.668450	6.744180	57.23912	848.7188

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	53688.09375	17896.03125	5.46	0.0062
trt	7	85027.71875	12146.81696	3.71	0.0091

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	53688.09375	17896.03125	5.46	0.0062
trt	7	85027.71875	12146.81696	3.71	0.009

Analysis of variance of individual variables for Lubbock 1997 location for micronaire.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1.04062500	0.10406250	8.20	<.0001*
Error	21	0.26656250	0.01269345		
Corrected Total	31	1.307187			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	mic Mean
0.796079	2.625846	0.112665	4.290625

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.03093750	0.01031250	0.81	0.5013
trt	7	1.00968750	0.14424107	11.36	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.03093750	0.01031250	0.81	0.5013
trt	7	1.00968750	0.14424107	11.36	<.0001

A.21

Analysis of variance of variables for Lubbock 1998 location for Cool Warm Vigor Index strata.

Stratum 1

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	2222.00000	222.20000	0.44	0.9115
Error	21	10685.87500	508.85119		
Corrected Total	31	12907.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.172143	21.80808	22.55773	103.4375

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1638.625000	546.208333	1.07	0.3817
trt	7	583.375000	83.339286	0.16	0.9899

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1638.625000	546.208333	1.07	0.3817
trt	7	583.375000	83.339286	0.16	0.9899

A.22

Analysis of variance of variables for Lubbock 1998 location for Cool Warm Vigor Index strata.

Stratum 2

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	9707.06250	970.70625	5.10	0.0008*
Error	21	3997.65625	190.36458		
Corrected Total	31	13704.71875			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.708301	10.45990	13.79727	131.9063

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	8092.093750	2697.364583	14.17	<.0001
trt	7	1614.968750	230.709821	1.21	0.3395

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	8092.093750	2697.364583	14.17	<.0001
trt	7	1614.968750	230.709821	1.21	0.3395

A.23

Analysis of variance of variables for Lubbock 1998 location for Cool Warm Vigor Index strata.

Stratum 3

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	11013.50000	1101.35000	8.81	<.0001*
Error	21	2625.37500	125.01786		
Corrected Total	31	13638.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.807508	8.722487	11.18114	128.1875

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	10643.62500	3547.87500	28.38	<.0001
trt	7	369.87500	52.83929	0.42	0.8772

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	10643.62500	3547.87500	28.38	<.0001
trt	7	369.87500	52.83929	0.42	0.8772

Analysis of variance of individual variables and interactions for Lubbock 1998 location for Cool Warm Vigor Index.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	0.28	0.9567ns
Strata	2	48	28.95	<.0001*
Treatments x Strata	14	48	0.44	0.9515ns

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	0.16	0.8554ns
Timing	1	21	1.48	0.2366ns
Chemical x Timing	2	21	0.04	0.9636ns
Untreated = Untreated Paraquat	1	21	0.00	0.9853ns
Control vs Treatments	1	21	0.05	0.8176ns
Untreated vs Treatments	1	21	0.04	0.8522ns
Untreated Paraquat = Treatments	1	21	0.03	0.8710ns
Chemical x Strata	4	48	0.22	0.9247ns
Timing x Strata	2	48	1.18	0.3162ns
Chemical x Timing x Strata	4	48	0.85	0.4998ns

* Significant at the 0.05 level of probability.

Analysis of variance of variables for Lubbock 1998 location for seed index values strata.

Stratum 1

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	3.83467500	0.38346750	0.76	0.6610
Error	21	10.54732500	0.50225357		
Corrected Total	31	14.38200000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.266630	8.693021	0.708699	8.152500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1.77777500	0.59259167	1.18	0.3412
trt	7	2.05690000	0.29384286	0.59	0.7605

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1.77777500	0.59259167	1.18	0.3412
trt	7	2.05690000	0.29384286	0.59	0.7605

A.26

Analysis of variance of variables for Lubbock 1998 location for seed index values strata.

Stratum 2

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	9707.06250	970.70625	5.10	0.0008*
Error	21	3997.65625	190.36458		
Corrected Total	31	13704.71875			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.708301	10.45990	13.79727	131.9063

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	8092.093750	2697.364583	14.17	<.0001
trt	7	1614.968750	230.709821	1.21	0.3395

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	8092.093750	2697.364583	14.17	<.0001
trt	7	1614.968750	230.709821	1.21	0.3395

A.27

Analysis of variance of variables for Lubbock 1998 location for seed index values strata.

Stratum 3

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	2.25580625	0.22558063	3.13	0.0131*
Error	21	1.51116562	0.07196027		
Corrected Total	31	3.76697188			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.598838	2.662820	0.268254	10.07406

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1.73605938	0.57868646	8.04	0.0009
trt	7	0.51974688	0.07424955	1.03	0.4389

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1.73605938	0.57868646	8.04	0.0009
trt	7	0.51974688	0.07424955	1.03	0.4389

Analysis of variance of individual variables and interactions for Lubbock 1998 location for seed index values.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	0.76	0.6297ns
Strata	2	48	215.74	<.0001*
Treatments x Strata	14	48	0.50	0.9227ns

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	2.11	0.1459ns
Timing	1	21	0.01	0.9186ns
Chemical x Timing	2	21	0.04	0.9629ns
Untreated = Untreated Paraquat	1	21	0.50	0.4853ns
Control vs Treatments	1	21	0.47	0.5002ns
Untreated vs Treatments	1	21	0.00	0.9578ns
Untreated Paraquat=Treatments	1	21	0.97	0.3365ns
Chemical x Strata	4	48	0.44	0.7759ns
Timing x Strata	2	48	0.22	0.8068ns
Chemical x Timing x Strata	4	48	0.36	0.8380ns

* Significant at the 0.05 level of probability.

Analysis of variance of individual variables for Lubbock 1998 location for yield.

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	109945.0625	10994.5063	3.73	0.0053*
Error	21	61935.4063	2949.3051		
Corrected Total	31	171880.4688			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	yield Mean
0.639660	10.27153	54.30750	528.7188

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	54409.84375	18136.61458	6.15	0.0036
trt	7	55535.21875	7933.60268	2.69	0.0372

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	54409.84375	18136.61458	6.15	0.0036
trt	7	55535.21875	7933.60268	2.69	0.0372

Analysis of variance of individual variables for Lubbock 1998 location for micronaire.

Dependent Variable: micronaire

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1.84562500	0.18456250	4.65	0.0015*
Error	21	0.83406250	0.03971726		
Corrected Total	31	2.67968750			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	mic Mean
0.688746	40.584717	0.199292	4.346875

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.12843750	0.04281250	1.08	0.3799
trt	7	1.71718750	0.24531250	6.18	0.0005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.12843750	0.04281250	1.08	0.3799
trt	7	1.71718750	0.24531250	6.18	0.0005

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Analysis of variance summary of variables for Olton 1998 location for Cool Warm Vigor Index strata.

Stratum 1

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	10290.25000	1029.02500	2.68	0.0275*
Error	21	8075.75000	384.55952		
Corrected Total	31	18366.00000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.560288	16.79674	19.61019	116.7500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1914.250000	638.083333	1.66	0.2062
trt	7	8376.000000	1196.571429	3.11	0.0205

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1914.250000	638.083333	1.66	0.2062
trt	7	8376.000000	1196.571429	3.11	0.0205

Analysis of variance of variables for Olton 1998 location for Cool Warm Vigor Index strata.

Stratum 2

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	6928.00000	692.80000	1.72	0.1411
Error	21	8446.87500	402.23214		
Corrected Total	31	15374.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.450605	13.21085	20.05573	151.8125

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	4548.125000	1516.041667	3.77	0.0261
trt	7	2379.875000	339.982143	0.85	0.5632

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	4548.125000	1516.041667	3.77	0.0261
trt	7	2379.875000	339.982143	0.85	0.5632

Analysis of variance of variables for Olton 1998 location for Cool Warm Vigor Index strata.

Stratum 3

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	5354.25000	535.42500	1.10	0.4033
Error	21	10185.62500	485.02976		
Corrected Total	31	15539.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.344549	13.97756	22.02339	157.5625

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	3492.375000	1164.125000	2.40	0.0965
trt	7	1861.875000	265.982143	0.55	0.7883

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	3492.375000	1164.125000	2.40	0.0965
trt	7	1861.875000	265.982143	0.55	0.7883

Analysis of variance of individual variables and interactions for Olton 1998 location for cool warm vigor index.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	21	1.37	0.2670ns
Strata	2	48	46.41	<.0001*
Treatments x Strata	14	48	1.23	0.2861ns

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	21	1.74	0.1993ns
Timing	1	21	0.03	0.8578ns
Chemical x Timing	2	21	0.06	0.9453ns
Untreated = Untreated Paraquat	1	21	2.67	0.1174ns
Control vs Treatments	1	21	3.32	0.0825ns
Untreated vs Treatments	1	21	0.10	0.7600ns
Untreated Paraquat = Treatments	1	21	5.99	0.0233*
Chemical x Strata	4	48	0.60	0.6619ns
Timing x Strata	2	48	3.26	0.0472*
Chemical x Timing x Strata	4	48	1.95	0.1177ns

* Significant at the 0.05 level of probability.

Analysis of variance of variables for Olton 1998 location for seed index values strata.

Stratum 1

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	57.34175000	5.73417500	22.99	<.0001*
Error	21	5.23693750	0.24937798		
Corrected Total	31	62.57868750			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.916314	4.747781	0.499378	10.51813

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	51.42286250	17.14095417	68.73	<.0001
trt	7	5.91888750	0.84555536	3.39	0.0140

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	51.42286250	17.14095417	68.73	<.0001
trt	7	5.91888750	0.84555536	3.39	0.0140

Analysis of variance of variables for Olton 1998 location for seed index values strata.

Stratum 2

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	44.71423125	4.47142313	43.12	<.0001*
Error	21	2.17746562	0.10368884		
Corrected Total	31	46.89169687			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.953564	2.670115	0.322008	12.05969

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	44.07030938	14.69010313	141.67	<.0001
trt	7	0.64392187	0.09198884	0.89	0.5335

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	44.07030938	14.69010313	141.67	<.0001
trt	7	0.64392188	0.09198884	0.89	0.5335

Analysis of variance of variables for Olton 1998 location for seed index values strata.

Stratum 3

Dependent Variable: wt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	49.97287500	4.99728750	12.22	<.0001*
Error	21	8.58551250	0.40883393		
Corrected Total	31	58.55838750			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	wt Mean
0.853385	5.070337	0.639401	12.61063

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	48.12343750	16.04114583	39.24	<.0001
trt	7	1.84943750	0.26420536	0.65	0.7134

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	48.12343750	16.04114583	39.24	<.0001
trt	7	1.84943750	0.26420536	0.65	0.7134

Analysis of variance of individual variables and interactions for Olton 1998 location for seed index values.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	69	2.28	0.0376*
Strata	2	69	144.21	<.0001*
Treatments x Strata	14	69	1.16	0.3247ns

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	69	1.39	0.2570ns
Timing	1	69	1.95	0.1673ns
Chemical x Timing	2	69	0.69	0.5063ns
Untreated = Untreated Paraquat	1	69	0.46	0.4993ns
Control vs Treatments	1	69	9.42	0.0031*
Untreated vs Treatments	1	69	3.52	0.0650ns
Untreated Paraquat = Treatments	1	69	7.64	0.0073*
Chemical x Strata	4	69	1.00	0.4150ns
Timing x Strata	2	69	40.87	0.0105*
Chemical x Timing x Strata	4	69	2.59	0.0442*

* Significant at the 0.05 level of probability.

Analysis of variance of individual variables for Olton 1998 location for yield.

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	69610.5625	6961.0563	1.25	0.3182
Error	21	116994.9063	5571.1860		
Corrected Total	31	186605.4688			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	yield Mean
0.373036	9.116034	74.64038	818.7813

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	6290.84375	2096.94792	0.38	0.7709
trt	7	63319.71875	9045.67411	1.62	0.1834

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	6290.84375	2096.94792	0.38	0.7709
trt	7	63319.71875	9045.67411	1.62	0.1834

Analysis of variance of individual variables for Olton 1998 location for micronaire.

Dependent Variable: micronaire

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.35000	0.035000	1.56	0.1861
Error	21	0.47000	0.02238095		
Corrected Total	31	0.82000			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	mic Mean
0.426829	5.391086	0.149603	2.775000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.14500000	0.04833333	2.16	0.1231
trt	7	0.20500000	0.02928571	1.31	0.2946

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.14500000	0.04833333	2.16	0.1231
trt	7	0.20500000	0.02928571	1.31	0.2946

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Analysis of variance of variables for Seminole 1998 location for Cool Warm Vigor Index strata.

Stratum 1

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	15827.50000	1582.75000	5.05	0.0009*
Error	21	6580.37500	313.35119		
Corrected Total	31	22407.87500			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.706337	18.91968	17.70173	93.56250

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	299.12500	99.70833	0.32	0.8121
trt	7	15528.375	2218.339	7.08	0.0002

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	299.12500	99.70833	0.32	0.8121
trt	7	15528.375	2218.339	7.08	0.0002

Analysis of variance of variables for Seminole 1998 location for Cool Warm Vigor Index strata.

Stratum 2

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	2185.31250	218.53125	0.28	0.9782
Error	21	16248.65625	773.74554		
Corrected Total	31	18433.96875			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.118548	18.72756	27.81628	148.5313

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	441.093750	147.031250	0.19	0.9020
trt	7	1744.218750	249.174107	0.32	0.9354

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	441.093750	147.031250	0.19	0.9020
trt	7	1744.218750	249.174107	0.32	0.9354

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Analysis of variance of variables for Seminole 1998 location for Cool Warm Vigor Index strata.

Stratum 3

Dependent Variable: CWVI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	2098.000000	209.800000	1.35	0.2697
Error	21	3268.875000	155.660714		
Corrected Total	31	5366.875000			

* Significant at the 0.05 level of probability

R-Square	Coeff Var	Root MSE	CWVI Mean
0.390917	7.203988	12.47641	173.1875

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	1721.125000	573.708333	3.69	0.0282
trt	7	376.875000	53.839286	0.35	0.9231

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	1721.125000	573.708333	3.69	0.0282
trt	7	376.875000	53.839286	0.35	0.9231

Analysis of variance of individual variables and interactions for Seminole 1998 location for cool warm vigor index.

Effect	Num DF	Den DF	F Value	Pr > F
Treatments	7	69	2.56	0.0209*
Strata	2	69	135.01	<.0001*
Treatments x Strata	14	69	1.92	0.0389*

* Significant at the 0.05 level of probability.

Contrasts	Num DF	Den DF	F Value	Pr > F
Chemical	2	69	0.49	0.6149ns
Timing	1	69	0.02	0.8964ns
Chemical x Timing	2	69	0.41	0.6643ns
Untreated = Untreated Paraquat	1	69	12.74	0.0007*
Control vs Treatments	1	69	3.38	0.0704ns
Untreated vs Treatments	1	69	13.88	0.0004*
Untreated Paraquat = Treatments	1	69	0.90	0.3468ns
Chemical x Strata	4	69	0.74	0.5652ns
Timing x Strata	2	69	1.52	0.2256ns
Chemical x Timing x Strata	4	69	0.82	0.5145ns

* Significant at the 0.05 level of probability.

Analysis of variance summary of individual variables for Seminole 1998 location for yield.

Dependent Variable: yield

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	451299.8031	45129.9803	3.39	0.0089*
Error	21	279650.5191	13316.6914		
Corrected Total	31	730950.3222			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	yield Mean
0.617415	13.34105	115.3980	864.9844

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	139670.3134	46556.7711	3.50	0.0336
trt	7	311629.4897	44518.4985	3.34	0.0149

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	139670.3134	46556.7711	3.50	0.0336
trt	7	311629.4897	44518.4985	3.34	0.0149

Analysis of variance of individual variables for Seminole 1998 location for micronaire.

Dependent Variable: micronaire

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	0.94062500	0.09406250	3.31	0.0100*
Error	21	0.59656250	0.02840774		
Corrected Total	31	1.53718750			

* Significant at the 0.05 level of probability.

R-Square	Coeff Var	Root MSE	mic Mean
0.611913	5.171113	0.168546	3.259375

Source	DF	Type I SS	Mean Square	F Value	Pr > F
rep	3	0.34093750	0.11364583	4.00	0.0212
trt	7	0.59968750	0.08566964	3.02	0.0234

Source	DF	Type III SS	Mean Square	F Value	Pr > F
rep	3	0.34093750	0.11364583	4.00	0.0212
trt	7	0.59968750	0.08566964	3.02	0.0234