# Synthesis of Gin Trash Utilization Research

Prepared For:

Dr. Sukant Misra

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Prepared By:

Jason Gembler

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### Introduction

Texas farmers grow on average 5 million bales of cotton a year. This represents over 20 percent of the cotton produced in the United States. The southern Texas High Plains produces over two-fifths of the cotton produced in Texas (Moore et al., 1982). Every year, around 2 million tons of gin trash is generated in Texas, from the cotton that is being produced and ginned (Parnell, 1977). In areas of the country that use strip harvest methods, especially Texas, Oklahoma, and New Mexico, the volume of gin trash produced are greater. Over 90 percent of the cotton produced in Texas is stripper harvested. While the amount of gin trash produced by strip harvest methods is usually 1000 pounds per bale of cotton, hand picking methods produce about 80 pounds per bale of cotton (Miller et al., 1975). Spindle harvesting methods produce 150 to 200 pounds per bale of cotton (Parnell, 1977).

The trash produced by gins contains primarily boll husk, stems and any other materials leftover from the ginning process. The ginning process is an intermediary step in the marketing channel for cotton, and consist of separating the cotton seed, lint, and waste products. The first step in processing is to clean the cotton seed and remove any leaves, twigs, pieces of boll, or sand. This is done with the use of a combination of shakers and revolving screens. The cotton seed then goes to the lint room. In the lint room there are delinting machines that consist of circular saws on a horizontal revolving shaft, and the saws project through a set of steel ribs. The cotton seed is then hulled, where a series of knives cut the hulls and loosen them from the kernels, then are separated through a series of shakers. 510 pounds of hulls are produced for every ton of cotton seed, on average.

Cotton gins in Texas, for many years, have been giving away gin trash to farmers to use as a soil enhancer and to ranchers for use as an alternative feed source for their cattle. Other end users for gin trash include compost producers and golf courses. There have even been times in the past where gins have had to pay individuals in order to dispose of the gin trash. Taylor (1995) estimates that at times, it costs the gins about $5 per ton to dispose of the waste. Some gins have had success in recent years in selling gin trash with market prices of $2 per ton (Taylor, 1995).

Due to the inadequate demand for gin trash, its disposal has become a major problem in Texas. Further, the burning of gin trash is restricted in Texas. Increases in disposal concerns raise further questions as to the alternative uses for gin trash. Although several studies have been done on the possible commercial uses for gin trash, there has not been a significant increase in demand for gin trash. The utilization of gin trash can have a significant impact on the Texas cotton industry, the overall economy, and the environment. The immediate impact will be at Texas cotton gins. Instead of having to pay for the disposal of gin trash, gins will be able to market the gin trash as a by-product, thus increasing revenues. If gin trash can be effectively used as a livestock feed, feedlots can reduce feed cost by substituting gin trash for alfalfa, coastal hay, and other feed sources. Farmers can potentially reduce production cost by using gin trash as a soil builder and a compost. This will also reduce the amount of chemicals being used in crop production, which will benefit the environment. The benefits to the environment include, reductions in ground water pollution, soil contamination, and losses of wildlife.

Research has been done in recent years, to make gin trash more digestible in cattle, thus bringing more attention to the marketing possibilities for gin trash as a livestock feed. Farmers are looking favorably towards the use of gin trash in organic compost. Organic compost has enabled the farmer to reduce use of chemical fertilizers and pesticides, which have come under scrutiny by environmental groups. Gin trash is also being used as a soil builder in areas with poor soil, and areas that use their soil extensively in crop production. Gin trash studies have been done on its usage as a silage additive. Studies have also been done on the conversion of gin trash into a water treatment aid and use as media component in vegetable production. The use of gin trash in energy production, especially during times when alternative energy sources have been in demand, also receives attention from researchers. Gin trash is also being considered in the production of building materials, such as particle board. However, these alternative uses have yet to become commercially successful.

Most of the studies identifying alternative uses for gin trash, focus on the physical characteristics of gin trash but fail to address the economic feasibility of identified alternative uses. The absence of an economic analysis makes it difficult for the producers, as well as consumers to determine the economic benefits of using gin trash. Further, many of these studies have not been published or are not in the public domain. Thus, the objective of the research is to identify and synthesize all available information. A synthesis of the available information could answer questions of what possibilities exist for gin trash utilization. A review of research on gin trash could identify areas of research that need further focus and would prove beneficial to future research in relation to the alternative uses for gin trash.

## Synthesis of Gin Trash Utilization Studies

The studies reviewed in this section are categorized into four subsections: The use of gin trash for energy, the use of gin trash in crop production, gin trash use in livestock, and a section that combines all other uses for gin trash. Each section is further divided into discussions on studies pertaining to physical characteristics of alternative uses of gin trash and economic analysis of gin trash use.

### The Use of Gin Trash for Energy

#### *Studies Dealing with The Physical Characteristics of Gin Trash*

Holmes (1979) explored the possibilities of using gin trash to power internal combustion engines. The main objective of the investigation was to develop a simple process to gasify cotton gin trash. Several tests were done using different types of gasifiers. Experiments were performed using gin trash as a fuel in updraft and downdraft gasifiers. This was done in an attempt to produce a gas that could be used in internal combustion engines on the Texas South Plains.

The first run used an updraft gasifier, that had success with crop residues. The engine was operated for 20 minutes and was fouled with tar produced by the upward draft gasifier. Attempts were made to reduce the tar emissions but the successful attempts proved to be too costly. The downward draft gasifier had difficulty reaching temperatures that were high enough to produce combustible gas. Several devices were added to increase the temperatures, but also proved ineffective.

Holmes's results showed the mechanical problems of tar build up and channeling of the gasification zone through the gin trash were probably a result of the fibrous, wood-like nature of the gin trash. Gin trash in pelletized form could be an adequate fuel when used in downward draft gasifiers that could be operated using a granular solid. Another alternative discussed was to turn the gin trash into charcoal and then use the charcoal as fuel in the gasifier. This method however, produced channeling and only a small amount of gin trash was converted to charcoal.

Holmes did not include an economic analysis in his study. He did mention however, that pelletizing gin trash would increase its cost to $3 per million Btu's and was still more economically feasible than charcoal briquettes that cost $9.5 per million Btu's. A study on the cost of gasification could help to further determine the economic feasibility. A study should also be done showing the economic feasibility of processing gin trash into charcoal.

Lalor, et al. (1976) studied the effects of a heat recovering gin-waste incinerator. The objective of this study was to determine the efficiency of a heat-recovering incinerator. The test was performed at a gin that had a 24 bale per hour processing capacity. Most of the drying heat for cotton, came from gin trash that was burned in the incinerator.

In this study, a 480 pound bale of lint on a moist basis, produced 140 to 260 pounds of gin trash. On a dry weight basis gin trash averaged 80 to 200 pounds of a bale of lint. The true gin trash content is derived on a dry weight basis to avoid overestimates.

The gin trash is fed through two incinerators by auger conveyers that carry the trash from the trash fans. The incinerators were capable of handling a 240 pound bale of trash each incinerator. The overall heat recovery efficiency of the incinerator system was 10 to 15 percent. Under conditions of 30 to 35 percent heat recovery, all but the wettest cotton could be dried effectively. The drawback to the incinerator was that it depended on the availability of gin trash. Wet cotton conditions would limit the amount of gin trash and would also limit the heat available to dry the cotton that would lead to a shutdown in the system or rely on heat from gas burners. The use of a surge hopper was noted to assure a supply of gin trash to provide fuel during conditions when there are high moisture levels in the cotton. Lalor, et al. did not recommend the use of the hopper due to the extra investment.

The results of the test showed that the incinerator eliminated 85 percent of the gas that would have otherwise been used. The heat exchanger was found to extract 10 to 15 percent of the heat released when the trash was burned. An additional heat capacity would have to be made to capture 30 to 35 percent of the heat that was needed to meet the gins drying requirements. The results also showed that there was a need for a means of dumping or exhausting unwanted heat. It was found that improvements were needed in the drying air control temperature systems as well as warning system for high variances in temperatures. In order to clean the ash from the system, a provision was needed to prevent cooling in the incinerator. The particulate concentration in the stack gas was found to cause a problem with pollution control agencies but performed extremely well in all other emissions testing.

Lalor, et al., did not include an economic analysis in their study. Lalor, et al., but did however, include cost figures that could lead to an economic analysis. The cost included an incinerator that was priced at $65,000 with an installation cost of $17,000. The incinerator was believed to have a 10 to 15 year life expectancy. Annual repair costs for the incinerator were estimated at 6 percent or $4,920. Repair cost with the addition of a $21,631 capital recovery cost brought the annual coat to $26,551. A recovery and repair cost of $3.24 was estimated for 8,200 bales over five year period. Labor costs in this study were calculated at $3 per hour. A cost saving of 34 cents per bale was calculated. The disposal cost for gin trash was $1 per bale and the disposal cost was eliminated since the incinerator also served as a disposal method.

A present analysis should be performed to reflect changes in operating and labor cost. An analysis should also compare cost efficiency as compared to other methods of heating and trash disposal.

### *Economic Analysis for Gin Trash Use in Energy*

Srikanth (1985) looked at the use of gin trash as a gaseous fuel. The objective of this study was to show that clean gas could be obtained from gin trash through downdraft gasification. Several gasifiers, such as up draft gasifiers, fluidized bed gasifier, and downdraft gasifiers were compared in the study.

The downdraft gasifier proved to be the most advantageous when the gin trash had been compacted, thus preventing channeling. The gasification process included many steps. After observing the gas lines it was noted that no oil deposits were found. The reactor used was found to have had some drawbacks. It was originally designed as an updraft unit and later converted to a downdraft unit for use in the study. There was a loss of 500 C from the gasifier. A commercial unit would have captured most of the lost energy. The gin trash was shipped to Ferro Tech and densified by roll compaction. This was a costly process that resulted in poor investment potential. The closest alternative was a stirred downdraft gasifier that did not require the compacting of gin trash, but at the time was not available commercially.

Srikanth's economic analysis was based on West Texas cotton gins. Three sizes of gins were used in determining the economic feasibility of gasifyng gin trash. The sizes used were gins that produced 7, 14, and 21 bales of cotton per hour. The biggest variable in determining the economic feasibility was the length of the harvesting season. Other factors included equipment cost, electricity cost, trash harvested per bale, interest on borrowed capital, and dryer fuel required per bale. The annual income was directly proportioned to the length of the ginning season. Larger gins benefited the most from extended ginning seasons. Srikanth found that gins producing 14 and 21 bales per hour had annual incomes of $11,228 and $41,553 respectively. However, gins that produced 7 bales per hour recorded an annual loss. It was also found that larger gins received the greatest benefit from extended ginning seasons. Annual income increased $13,65 per hour for 7 bales per hour operations, $106.17 per hour for 14 bale per hour gins, and $182.86 per hour for 21 bale per hour gins. Srikanth did mention however, that extending the ginning season by seed cotton storage is only feasible if the local cotton growers invested in moduling equipment. The greatest potential found to increase profitability in a fixed season length and gin size was obtained by reducing the cost of conversion equipment. A 20 percent reduction in equipment cost resulted in an increase of annual income by $18,850 and $25, 375 for the 14 and 21 bale per hour gins. The 7 bale per hour gins were not included in the remainder of the analysis due to reported losses at all levels of utilization. Increases in the cost of electricity sold to power companies generated additional revenue for the gins. A 10 percent increase in the cost of electricity resulted in an increase in annual income of $13,000 and $15,000, for the 14 and 21 bale per hour gins. Increases in the amount of gin trash produced per bale of cotton increased income as well. A 100 pound increase in gin trash produced per bale, raised the annual income of 14 and 21 bale per hour gins by $10,000 and $13,750. Efficiency improvements in the gasifiers resulted in additional energy production, increasing annual income by $16,500 and $22,000 for the 14 and 21 bale per hour gins. Changes in natural gas usage had the least impact on the economics and were set as a standard case value in the remainder of the analysis. Srikanth concluded that investing in energy conversion systems was not profitable for 7 and 14 bale per hour gins at that time. It was profitable however, for the 21 bale per hour gins to invest in the energy conversion equipment.

This analysis was conducted in 1985 and a present analysis should be performed to indicate ant changes in economic feasibility, due to increases in technology, efficiency, and changing market prices and economic conditions. Changes in economic condition could tell a different story as to the economic feasibility of 7 and 14 bale per hour gins investing in energy conversion equipment.

Moore, et al. (1982) looked at the use of pelleted gin trash as an alternative energy source. The objectives of this study, was to estimate the amount of gin trash produced in the Texas High Plains and determine the yearly fluctuations in gin trash production, as well as the total heat content that can be converted from gin trash for commercial use. Another objective was to determine the cost of the pelleting process, and the sensitivity to cost. The last objective was to determine the potential problems of pelleting gin trash to use for energy.

It was estimated, that 700 pounds of gin trash came from a bale of cotton. Gin trash content was broken down on a dry basis. The physical composition was 7.7 percent lint, 56.6 percent burs 10.7 percent sticks, and 24.9 percent fines. The chemical properties of gin trash included 42 percent carbon, 5.4 percent hydrogen, 1.4 percent nitrogen, 35 percent oxygen and error, and less than 0.5 percent sulfur. In order to determine the total produced in the High Plains 700 pounds was multiplied by the number of bales produced in the High Plains. This calculation could be used for all areas using stripper harvest methods.

However, the amount of gin trash produced should vary and be accounted for in the calculations. Only clean gin trash can be used for energy purposes. Arsenic and other chemicals caused environmental and control problems. High Plains cotton was more desirable due to the low levels of chemicals used in the area. The seasonal nature of ginning caused a supply problem for energy producers and meant a requirement of gin trash on an annual basis. The fine trash produced by gins, called "fines" makes up one-tenth to over one-third of the total gin trash content. Fines have been found to clog combustion equipment, which created a need for the gins to remove the fines, thus increasing ginning cost. The gin trash used in the study came from 231 area gins. The gin trash was stored in modules and storage space was leased at 1 acre for every 50 modules. The modules used in this study were 32 feet long, and 8 feet wide. Gin trash averaged 7000 Btu's per pound. This estimate varied depending on the level of moisture and difference in the constituent parts of the material. The figure of 7000 Btu's was based on a moisture level of 11 percent. Moore et al.'s figure, however, did not include the removal of fines or the losses incurred in the process of storing and transportation. Moore, et al. illustrated the many physical considerations that must be considered when looking at gin trash as a potential alternative energy source. There is definitely a potential for the use of gin trash as an energy source and the solutions to the existing problems would certainly increase the feasibility.

Moore, et al. created an economic analysis for using pelleted gin trash as an alternative energy source. Four costs were determined in this study. The cost included the payments to gins for the gin trash and the removal of the fines, moduling cost, and transportation and storage cost of modules. A removal cost of $5 per ton was estimated for the fines. The initial cost of the modules was $20,000 and fixed and variable costs were estimated on a per ton basis. A rate of

$4.50 was estimated for labor. The costs were estimated for operations that produced 5,000 bales per year. Gins producing less than 5,000 per year experienced higher per ton cost. The moduling costs per ton were as follows: $1.86 for investment, $.22 for labor, $.38 repairs, and $.40 for power. Tarps and pallets were needed to store the gin trash and the per ton cost was: $7.54 for investment and $.64 for repairs. There was an annual flat charge of $2000 per gin for module storage cost, plus a charge of $2 for every 20,000 pound module. Transportation took place by truck and costs were estimated by using the current rates provided by the Texas Railroad Commission. Pelleting cost included a cost of electricity at $.06 per kwh. Diesel fuel and lubes cost an estimated $.85 per ton of feedstock. The cost of repair was $5 per ton of feedstock produced. Total pelleting cost varied from $36.90 to $35.90 depending on the distance of the gin from the pelleting operation.

The conclusions showed that it would cost between $2.20 and $3.89 per million Btu's to produce pelletized gin trash in Lubbock. This figure did not include the distribution cost. Gin trash was competitive with the average natural gas price of $3 per million Btu's and $7.57 per million Btu's for diesel fuel. Coal and Texas lignite however, had a cost of $1.66 per million Btu's and $.92 per million Btu's respectively. The results showed that at the time gin trash had an advantage over diesel and fuel oil, but were at a cost disadvantage with coal and natural gases.

Future studies should include present market conditions, that could show any variations in cost that could show gin trash's present position in relation to coal and natural gas. A study should also be performed to investigate storage techniques that would reduce losses that have been incurred in the storage of gin trash. Future studies should also demonstrate efficiency advances, due to new technology. Future studies could also reflect on changes in the economy such as raise's in the minimum wage or effects of imports on domestic cotton prices due to changing legislation and policy.

Lacewell, et al. (1981) studied the use of gin trash as an energy source. The main objective of this study was to determine whether gin trash can be converted to an energy source that could be used to power a cotton gin. If successful, this would eliminate the waste disposal problem for gin's and result in savings in electricity and disposal cost. The gins would have been able to increase revenues through the sale of surplus electricity to local distributors.

The methods used by Lacewell, et al. involved the generation of electrical power and low-Btu (British thermal unit) gas generation from cotton gin trash. A fluidized-bed combuster was used in the production of low-Btu gas in conjunction with a boiler and turbine were used to produce electricity. The fluidized-bed combuster had a chamber of sand-like particles (which absorbed heat) supported by a porous floor, and air pressure was forced through both the floor and the particles. Turbulence in the bed maintained a uniform temperature. After the gin trash was added, the bed rapidly absorbed the heat from the solid particles until they ignited and burned. This produced low grade fuels of non uniform size and varying moisture content that burned efficiently. The heat produced in the fluidized-bed was used to heat the boiler. Considering an operation of 341 days per year, gin trash was consumed at a rate of 25.6 million Btu's per hour.

The process to produce low-Btu gas was similar to the previous process. There was variation where the level of oxygen used was significantly reduced. The gasification process also eliminated the need for the boiler and turbine. The fluidized-bed was used at a 61 percent efficient level of energy input to energy output available as gas in the gasification process.

The results showed that the combustion unit produced 7,775 Mwh (megawatt-hours) per year, 2,400 Mwh was used for ginning and 12 billion Btu's of natural gas was used to dry the cotton. This eliminated the waste disposal problem at the gin sites. This also resulted in a cost saving of energy cost and permitted the sale of surplus electricity. The waste heat that was produced was used to dry the cotton.

The economic analysis performed by Lacewell, et al. was based on a 40,000 bale per year gin and used only the gin trash produced by that gin. The production of energy required an investment of $868,400 and cost $15,000 per year to module the gin trash, along with $132,000 in variable cost in operations. The gin realized a cost savings of $126,000. That was due to the cost saving from energy that was not purchased, the sale of surplus electricity and the cost savings from the elimination of gin trash disposal. Gin trash disposal cost gins $2 per bale, at the time this study was performed. The electricity that was produced at the gin sold for 2 cents per kwh (kilowatt hour). This resulted in an income of $107,500 to the gin. The total credit for electrical generation was estimated at $233,500 and the total cost of electrical generation was $300,000 that left $66,500 in expenses. This was only $1.66 per bale from being economically feasible. With the elimination of trash disposal at $2 per bale gin realized a profit of 34 cents per bale. The end result showed that electrical generation was economically feasible in this case.

The cost of low-Btu gas production involved the investment of a fluidized bed at $520,000 and production cost of $239,040. The gin produced 127.7 billion Btu's. The cost per million Btu's was $1.87 which, was very competitive with the market price of natural gas at that time. The cost estimate did not however include distribution and gas cleanup cost.

Lacewell, et al. study did not include storage cost for gin trash or maintenance cost. The study also assumed that the energy was sold on the wholesale market with no difficulty or cost. Though the study appeared to show that energy production was economically feasible a present study should be performed to show present market trends. A present study should also include the changes in labor, investment and operating cost. A study should also be performed showing the potential for generating gin trash into energy as a sole means of energy production that would be produced at larger areas to compete in a given market.

### *Summary*

Gin trash has potential as an alternative source of energy. Lalor et al. revealed that gins who generated energy from gin trash benefited from the sale of energy to producers. Gins also benefited but from a cost savings in having the ability to use the energy that the gins generated. Lacewell et al. pointed out that gin trash used for energy purposes not only created revenue to gins, but also eliminated waste disposal problems which has become a major issue within recent years.

## Gin Trash use in Crop Production

### *Studies Dealing with Physical Characteristics of Trash in Crop Production*

Logsdon (1993) studied the use of gin trash in composted manure. The author reported results of an experiment conducted by the Birkenfield brothers. The problem in this situation was that the soil in their region was too compact, leaving large clods after the land had been chisel plowed. The general objective was to find a compost that would improve soil quality and texture.

The Birkenfield brothers applied 2 to 3.5 tons of gin trash per acre. The gin trash was mixed with manure in the windrows at one-third gin trash to two-thirds manure by weight. The Birkenfield brothers used front-end loaders to do this and combined two scoops of gin trash to four scoops of manure. The gin trash was obtained free, except for a hauling charge. The compost sold for $12 a ton on site, 15 cents per ton per mile to haul it, and there was a $5 per acre fee to apply the compost. The Birkenfield brothers, applied 12,000 tons to their own soil and sold another 10,000 to 12,000 to other users.

After applying the compost, the brothers found that the compost supplied sufficient plant nutrients and raised the organic matter content significantly. The compost also protected peanuts and sugar beets from many different soilborne and fungal diseases, according to area farmers. Repeated use of the compost also showed dramatic increases in microbial life, such as the earthworm population.

Edwards (1994) studied the problem of the seasonal application of organic compost and the results of using compost in different seasons. This study was done in response to four decades of failure to maintain soil conservation practices that lead to declines in soil productivity, increased soil erosion, and losses of soil organic matter content. It needed to be determined when was the better time to apply organic compost and what would be the effect of applying compost in different seasons.

Different combinations of organic mulches were used in various seasons and it was determined that newsprint and gin trash applied in the fall reduced weeds the most on cropland. After three annual applications, it was determined that gin trash and newsprint reduced summer crabgrass and significantly reduced crabgrass seedlings. Soil content was raised from 9.5 to 17g per kg after two annual applications of gin trash. There was no mention of any preparation being done to the gin trash before application or that any preparation to the gin trash could change the effectiveness once applied to the cropland. Edwards did not report any cost associated with composting the gin trash or any economic benefit as a result of composting.

Parnell (1980) looked at the composting of gin trash with the objective of determining whether or not gin trash could be safely utilized. The gin trash was composted in bins made of wood frames, cement blocks, and oil drums. The composting resulted in the destruction of Verticillium wilt organisms. It was also found that gin trash already contained the micro-organisms needed for composting and that gin trash contained nitrogen contents approaching 3 percent of dry weight. Stirring and mechanical aeration was needed for uniform moisture distribution. By composting, the gin trash volume could be reduced by 60 percent and dry weight by 50 percent.

Parnell found that composting is a feasible utilization of gin trash and could find markets especially as a potting soil amendment. These results show that there is a market potential for gin trash as a compost component and further studies could demonstrate the physical benefits of using gin trash as a compost component.

Millhollon et al. (1977) studied the effects of gin trash as a soil additive in cotton production. The test was composed of two treatments that were replicated five times. Gin trash per acre was applied at a rate of 2 tons per acre, prior to seed bed preparation. The results were compared to a check of normal seed bed preparation. Between 1978 and 1982, decreasing amounts of nitrogen were added as anhydrous ammonia. Seven years after applying the gin trash in the cotton field, Millhollen observed no increase in cotton yields. Organic matter, on the other hand, increased over 50 percent compared to the check.

The study did not observe any economic benefit to the producer in applying the gin trash to the cotton crops. However, producers would benefit from applying gin trash as soil builder. Gin trash reduced the amount of chemicals used thus, reducing environmental and social cost.

Pessarakli and Tucker (1994) studied the effects of gin trash as a compost on the growth of tomato plants. The first objective of this study was to evaluate the beneficial effects of small amounts of gin trash compost added to the soil as an amendment. The second objective set out to evaluate the potential of compost as a potting mix, by addition of varying amounts of compost to soil that can be used by homeowners. The compost was mixed with two types of soil in various ratios and placed in pots with tomato plants in greenhouses.

The results showed that a 3:1 ratio of gin trash to chicken manure with a 1:5 application on soils was the most beneficial on plants and was suitable for practical composting. The experiment indicated a positive correlation between the rate of compost application and the fruit yield of tomato plants. It was also found that an increase in the application rate caused an increase in dry matter production. Thus it was determined that the produced compost can be used as an amendment and soil conditioner and was beneficial to plant growth and crop yield.

Pessarakli (1990) addressed the problem of agricultural waste in his study on gin trash disposal. The objective of Pessarakli's study was to determine suitable composting conditions. The researcher also attempted to find the optimal proportions of gin trash to chicken manure for the systematic production of uniform compost. This was done in order to reduce the volume of disposed waste and eliminate the pollution problem inherent to burning gin trash.

Three proportions of gin trash and chicken manure were studied to find the minimal time required to develop the desired compost. The proportions consisted of ratios of 1 gin trash: 1 chicken manure, 3 gin trash: 1 chicken manure, and 5 gin trash: 1 chicken manure. These ratios were determined using pyramid shaped piles measuring 2m x 2m, at the base 1.3m x 1.3m at the top, and 1.75m in height. The piles were turned every 15 days. Four 1m x 1m x 1m boxes were made and two piles of 1:1 and 3:1 were formed in the boxes to test the effect of higher initial water content. Another 1.75m x 1.75m x 1.3m high pile was formed and tested using the Berkeley method. This pile was turned on the 4th day and repeated on the 7th and 10th day that resulted in a finished product on the 14th day. Water was added to the piles 50 percent by weight to each level of the piles. A soil thermometer and three thermocouples were used to measure the piles' temperatures. The thermocouples were located in various locations of the piles. Average temperatures were collected daily for each pile as well as NH3 evolution and Ammonia volatilization. The piles were turned every 15 days and inverted coffee cans were placed on the piles to act as a trap.

The findings revealed that the 3:1 ratio produced the finest particles and the most uniform composted material. The 3:1 ratio also proved to be the most beneficial to plants where growth and dry matter production are concerned. The time required to compost gin trash is greater than for many materials because of the resistance of the cotton fiber to decomposition. Nevertheless, composting gin trash may provide a product that would be useful in numerous urban applications, and at the same time reduce the waste disposal problem of livestock, poultry, and ginning operations.

Buckley (1994) researched the possible use of gin trash as a media component in vegetable production in Louisiana. Buckley used six media ranging from 0-50 percent gin trash compost. The vegetables included in Buckley's research were, broccoli, cabbage, bell peppers, and tomatoes.

Buckley's results indicated that gin trash has a potential as a media component for vegetable production. In order for gin trash compost to be effective, it must be produced in a controlled manner to insure the destruction of weed seed and plant pathogens and to provide a uniform product. Further studies on yield improvements are needed to further demonstrate the possibilities of gin trash as a media component.

*Economic Analysis of Gin Trash Use in Crop Production*

Parnell (1977) discussed the possibilities for the use of gin trash in the production of compost. The objectives included: 1) Determining whether raising the moisture content in gin trash to a 60 to 70 percent would be sufficient enough to use for compost. 2) Determining the magnitudes of volume and weight decreases after composting. 3) Determine the fertilizer potential for gin waste compost. 4) Effects of composting on arsenic residues.

Parnell brought in 6 truckloads of gin trash and had the gin trash placed into 6 different piles. Over a 6 week period the gin trash was watered to maintain a moisture level of 70 percent. Temperature was taken at 3 different levels and locations in each of the piles. Some of the piles were mechanically aerated. The unturned piles had spots from anaerobic decomposition.

The results showed that temperatures increased dramatically to 120-140 degrees Fahrenheit after the first application of water. The piles' temperatures decreased continuously for the following weeks. After the tenth week the stirred piles reached a maximum temperature of 130 degrees Fahrenheit and subsequently declined. This resulted in a need for continuos stirring of the piles to insure proper composting. Without stirring weed seed and disease organisms would not be destroyed due to the low temperatures. Nitrogen contents increased by 50 percent in both the stirred and unstirred piles in the first nine weeks. Stirring the piles in the following three weeks resulted in another increase of 50 percent in nitrogen content, while the unstirred piles maintained a constant nitrogen content. The final nitrogen content for the stirred gin trash was 3 percent or an equivalent of 40 pounds of nitrogen per ton of gin trash. The oxygen demanded was decreased by 5 percent during the first nine weeks. Stirring resulted in another reduction of 10 percent and the unstirred piles decreased by 5 percent. Arsenic concentration levels rose from 193 parts per million to 353 parts per million. The total volume of the stirred piles decreased by approximately 60 percent along with a 50 percent reduction in dry weight.

This lead to a conclusion that arsenic compounds do not break down and that reductions in volume and dry weight result in increases in arsenic concentrations. The final observation concluded that it would not be practical to merely store cotton on the ground and add water. The unstirred piles presented a problem of odor and decomposition. The unstirred piles were brown in color and did not compost properly due to the uneven distribution of water, a result of the gin trash not being turned. The stirred gin trash on the other hand was almost black, contained little odor and was near to being completely decomposed. Stirring the gin trash accomplished two task, it supplied oxygen to the composting process and distributed the moisture in a more even fashion. The major problem with unstirred gin trash was channeling. Water would find paths through the gin trash and not get evenly distributed.

The results showed that stirring gin trash produced a more uniform product and increased the nitrogen content. Stirring needed to be performed when the temperature dropped below 120 degrees Fahrenheit. The most effective way to stir the gin trash required the use of a front-end loader. To be effective, the moisture content must be kept at 60 percent. A period of 90 days and 3 stirrings produced the best quality compost and rainfall improved the quality of the compost as well.

Future studies should be done that includes the  average temperature of the location where the study is performed as well as the relative humidity to determine the effects of location on the composting process.

Parnell's economic analysis determined that gin waste could be sold to golf courses at $10 per cubic yard. This price was the equivalent of $32 per ton at a moisture content of 30 percent. It was also found that the value of the gin trash compost should be given a value based solely on its nitrogen content. The gin trash was also found to have organic matter that increased the water holding capacity in other soils. A value of $12 per cubic yard or $40 per ton at a 30 percent moisture content would generate $48,000,000 to the Texas cotton industry.

An analysis should be performed exhibiting the cost of production to producers. This study should also include the cost of investing in machinery, such as a front-end loader. A cost benefit analysis could also display the cost saving to ginners that produced their own compost. A market analysis should also be performed to determine the competitiveness of gin trash compost in relation to other component compost

Goldstein (1994) looked at the problem of how farmers can reduce the use of pesticides on cropland. The objective was to determine the benefits of using compost containing gin trash. Goldstein worked with the New Era farm service, a producer of organic compost. New Era farm service, provided compost to over 500 farmers that represented an area of over 500,000 acres. New Era produced 100,000 tons of compost each year. The compost came from 12 different sites and sold for $17 per ton plus freight.

Organic compost was being used by farmers to cut down on the use of chemical fertilizers, pesticides, and herbicides. Farmers that used the compost saved $35 per acre in defoliation cost as compared to uncomposted crops.

Further, Goldstein spoke with Jack Pandol Jr. of Pandol and Sons Inc., who farmed 6,000 acres of vegetables, tree fruits, and grapes. Pandol and Sons reduced the usage of pesticides by 80 percent in three years by using New Era's gin trash compost.

Goldstein's quotation of Ralph Jurgen concluded that: "Properly made compost and composted products could enhance conventional cropping systems and conventional fertilizers, making them more efficient. Therefore we can use less commercial fertilizer." A study showing crop yield benefits would also be of great benefit further illustrating the benefits of utilizing gin trash.

### *Summary*

Gin trash has great potential for use in crop production. Organic compost was the primary consideration that was studied as a possible use for gin trash. Gin trash shows great potential for use as a compost. The gin trash was found to improve soil content levels, reduce weed seed, and reduce the level of insects. Edwards noted that gin trash application was effected by seasonal conditions. Gin trash was also found by Parnell to produce a better compost when it has been mechanically aerated. Parnell also noted that gin trash could be used as a potting soil amendment. Logsdon pointed out that producers using gin trash compost reduced defoliation cost. It was also stated that composting gin trash would reduce the disposal problems of gin trash. Goldstein mentioned that gin waste compost reduced the amount of pesticides used by producers. This is especially important to producers that face opposition from environmental groups.

## Gin Trash Use in Livestock

### *Studies Dealing with Physical Characteristics of Gin Trash*

Kabala (1994) studied the use of gin trash as an additive in silage. The problem in making the silage was that excessive wilting in forage lead to increased nutrient losses and a decrease in digestibility in small ruminants. The objective of this study was to determine the chemical feature in vitro digestibility of alfalfa silage's ensiled either wilted or as a mixture of fresh CT-CGT (ozone-conoxyl-treated cotton gin trash). The objective of the study was also to measure the effects of feeding silage as a part of the ration of growing lambs on their performance.

The methods and procedures used in this study included a statistical analysis using the Duncan Multiple Range Test to differentiate between the means of in vitro digestibility vale and performance data of lambs. The ensiling procedure consisted of ensiling sun wilted alfalfa and alfalfa with CT-CGT in large plastic containers for 60 days. Twenty Assaf lambs were divided into groups and fed rations, which contained 25 percent silage. The growth experiment lasted about 67 days. The lambs were weighed in 14 day intervals. The weighings were done before the morning feedings. The last weighing was on the day of the slaughter and the carcass was weighed after the internal organs were removed. Silage samples were removed with distilled water where the extract was used to determine pH, lactic acid, ammonia and other various content levels.

The findings showed that conoxyl treated gin trash improved nutritional content and high content of DM when used as a silage additive. CT-CGT can successfully be used as silage additive for direct ensilage of fresh alfalfa thus, resulting in intensive growth. Using locally grown forages can replace half of the amount of imported concentrates used for the feeding of growing lambs.

However, Kabala's study did not discuss the economic benefit of using gin trash a as silage additive.

Whiting and Schuh (1988) examined the use of gin trash in the diets of growing dairy heifers. The objective of the study was to evaluate the use of gin trash in controlling energy intake and preventing over conditioning in dairy heifers that are fed alfalfa hay diets. Eighteen Holstein heifers that averaged 288 kg in body weight and an average age of 328 days were used in the study. The heifers were fed 3 rations using combinations of alfalfa hay cubes (AHC) and loose cotton gin trash. The 3 rations consisted of; 1) 100 percent AHC. 2) 65 percent AHC and 35 percent gin trash. 3) 55 percent AHC and 45 percent gin trash. The mixtures of AHC and gin trash were blended at feeding. The animals were fed in groups twice daily ad libitum. The heifers were allowed free choice salts, mineralized salt, and dicalcium phosphate. The heifers were weighed every 2 to 3 weeks and on the first breeding and post postpartum. The heifers were artificially inseminated at 15 to 16 months of age. After parturition, heifers went to a milking herd and feed and handled the same during lactation.

The gin trash used in the study contained more cotton and immature seed than normal. The ash content was comprised of mainly dirt causing dust residues that made the gin trash difficult to handle and required frequent cleaning of the mangers. Subsequent to the first breeding heifers that were fed 35 percent gin trash grew up to 10.5 percent faster than heifer that were fed the other diets. After the first breeding AHC ration heifers had a 35 percent higher daily gain than the gin trash rations. The results showed that heifers over a 16 month period gained 0.71 kg per day using AHC, 0.62 using 65 percent AHC and 35 percent gin trash, and .59 kg per day using 55 percent AHC and 35 percent gin trash. Though the weight gained using gin trash were slightly lower all the heifers calved at acceptable ages with minimal calving complications.

Heifers that were fed 35 and 45 percent gin trash rations produced 9 and 24 percent more milk than heifers fed AHC rations. The heifers fed on the 45 percent gin trash ration were heavier at calving and demonstrated higher degrees of body conditioning and sleeker hair coats. The amount of AHC was reduced by 807 and 1,332 kg by heifers fed the 35 and 45 percent rations, however, the amount of feed consumed increased by 22 percent. The actual intake of gin trash in these diets was 32 and 42 percent.

Whiting and Schuh did not include an economic analysis in there study of the use of gin trash in the diets of dairy heifers. An analysis determining the economic feasibility of using gin trash in dairy cattle feeding could demonstrate whether or not the producer could benefit from the use of gin trash in their operations. Whiting and Schuh did say however, that producers would benefit from using less alfalfa in amounts ranging from 800 to 1300 kg less per heifer. Depending on the market price for gin trash and alfalfa could result in a considerable cost savings to the producer and further studies should be conducted to test the validity of those statements. Studies should also be performed testing the economic feasibility of pelleting the gin trash and determining the most economically feasible method of pelleting the gin trash. Cost comparisons should also be considered towards other low quality roughage's and other regularly used feed sources.

Whiting and Schuh's results concluded that young heifers have the ability to utilize lower quality roughage's in their daily diets. It was also determined that using gin trash as an alternative feed source could create a cost saving to producers. The only drawbacks that were found with the loose gin trash was the dust content and difficult handling. Whiting and Schuh recommended that cubing and screening the gin trash would alleviate the problems. Another possible concern was the chemical residues that remained in the gin trash that could contaminate the gin trash causing it to be unfit for cattle consumption. Further work needs to be done showing the effects of gin trash that has been chemically treated to increase feed value. Further emphasis should also be given to pelleted and cubed gin trash to determine any changes in feed value or acceptance among cattle.

Conner (1985) examined the use of chemically treated gin trash in the feeding of ruminants. Conner's primary objective was to determine the potential of adding ammonia to gin trash in order to improve the digestibility and feed value in feeding ruminants. The ruminants studied were limited to steers and lambs.

The gin trash used in these experiments came from a single source to insure consistency. The gin trash was ground through a hammermill using a 1.59 cm screen in experiment 1. The gin trash in experiment 2 was not ground, resulting in particle sizes that were as large as 10.16 cm in length. In experiment 1, feces and urine was collected from 10 wether lambs that were kept in wooden metabolism boxes. The boxes were a 5 x 5 Latin design, with one lamb per cell.

Conner found that ammonia treated gin trash offered some promising results. However, the metabolism trials failed to demonstrate any improvement in digestibility after treating gin trash with ammonia. The metabolism trials did however, show an improvement in cellulose availability. The sheep's metabolism showed an increase of 11 percent with an addition of ammonium hydroxide when compared to the control treatment and 23 percent when compared to the water treatment. The cattle metabolism trial showed a 9 percent increase in cellulose availability compared to the control treatment when the level of ammonium was increased to 8 percent. Gin trash with 4 percent sodium hydroxide increased cellulose availability by 24 percent compared to a control treatment and 14 percent when compared to a treatment of 8 percent ammonium. Sodium Hydroxide showed the best opportunities for nitrogen utilization and cellulose availability. Results were more obvious in the feed lot trials. Comparing ammonium and sodium hydroxide showed an increase of 9.2 percent in the rate of gain and an increase of 7 percent in feed efficiency due to the ammonia treatment of gin trash. These results were believed to come from improved energy availability and improvements in the use of ammonia nitrogen when compared to that of urea in the water treatment.

### *Economic Analysis of Gin Trash Use in Livestock*

Young and Griffith (1976) studied the use of gin trash in feedlot rations on the Texas High Plains. There were three objectives in this study. The first objective of the study was to determine the optimum quantities of gin trash that could be used in cattle feedlot rations. The second objective set out to determine the value of gin waste in feedlot lot rations relative to other roughages. The third objective was to compare the costs of processing and transporting gin waste products with alternative methods of processing. Studies revealed that cotton was similar to alfalfa in energy content and only slightly lower in total digestible nutrient content. Cotton burr pellets were processed from gin trash and compared to alfalfa pellets. Feed utilization significantly improved with alfalfa pellets relative to burr pellets. Cows that were fed burr pellet's loss weight prior to calving, yet continued to gain weight after calving. It was found that cattle feeders add molasses to the gin trash to increase palatability and provide additional energy.

Young and Griffith provided market information for all of the roughages used in the study as well as the processing cost and market values for gin trash. Cost of gin trash was assumed to be $3 a ton. Transportation cost was $0.20 per ton-mile on short hauls and $.09 per ton-mile for long hauls. This resulted in a price for ground trash at the feedlot ranging from $11 per ton for a 5-mile haul to $16.75 per ton for a 75-mile haul. Gin trash that is pelleted at the gin reduced transportation cost by 50 percent. This resulted in delivery charges ranging from $12.50 per ton for a 5-mile haul to $15.50 for a 75-mile haul. This also resulted in pellets having more appeal to feedlots that were a long distance from the gin and ground gin trash having more appeal to feedlots in close proximity to the gin.

The feed value for gin trash was $24.4 per ton with molasses and $22.8 without molasses. Gin trash prices were influenced by milo and cotton hull prices as well as energy and fiber restrictions. Ground gin trash was also more economical than pelleting.

Gibson, et al. (1995) studied the use of gin trash treated with Radex® in feedlots. The objective of this study was to determine: 1) the potential for gin trash as a feed supplement when treated with Radex®. 2) Determine the economic benefit to the cattle industry. 3) Determine the economic benefit to the cotton gin industry. This study focused on the Texas High Plains, consisting of a 12 county area contained within the Parmer-Briscoe-Crosby-Cochran county perimeter. Only the feedlots and gins located in this perimeter were considered in this study. Gibson, et al. compared cost and nutritional values of gin trash to alfalfa on a per ton basis. Feedlots depend on roughages for 10 percent of the cattle's total diet. At 10 percent, producers required 200 pounds of roughage per head of livestock for a 120 day period. Loose gin trash was preferred less by producers because of its low palatability and difficult handling, due to its bulky size. Pelleted gin trash, had a slightly higher nutritional value but was not high enough to be considered in the study. Pelletized gin trash was also found to be more palatable when molasses was added. Pelletized gin trash also reduced waste and was easier to handle.

Gin trash was compared to alfalfa on a loose and pelletized basis assuming an average price for alfalfa to be $103.26 per ton. It was also estimated that gin trash treated with Radex® was 80 percent digestible (35 percent untreated) when compared to alfalfa. Radex® could be added directly to the gin trash feed or given to the cattle in mineral blocks. The processing and delivery cost was estimated at $10 per ton, assuming that the gin trash was not shipped over 15 miles from the gin. The estimated cost of Radex® was $4 to $7 per ton.

Gibson, et al.'s economic analysis used loose treated gin trash and pelletized gin trash in comparison to alfalfa. The first analysis used loose gin trash treated with Radex®. The current price of loose treated gin trash ranged from $20 per ton ANEW (alfalfa nutritional equivalent weight) to $23.75 per ton ANEW. The equation $Pd = Pa - 1.25(Pgt + Pde + Pt)$ was used to determine the price differential between loose gin trash and alfalfa, where $Pd$ = price discrimination $Pa$ = price of alfalfa, 1.25 = ANEW, $Pgt$ = price of gin trash per ton, $Pde$ = price of digestion enhancer per ton of gin trash, $Pt$ = cost of cleaning, grinding, and hauling. The price differential between loose gin trash and alfalfa was $83.26 per ton when the price of Radex® was estimated at $4 per ton of gin trash and gin trash cost $2 per ton. The results of this study revealed that cattle producers would pay as much as $70 per ton for Radex® to treat 1 ton of gin trash when the price of gin trash was $2 per ton. Producers used alfalfa when the price of Radex® was held constant at $4 per ton of gin trash and the price of cotton gin trash varied. The results showed that under current price conditions treated gin trash would create a greater cost savings to producers. The only draw back to using gin trash in a loose form is handling difficulties, due to bulk and a lack of palatability.

The second test examined pelletized gin trash. Pelleting gin trash would overcome any handling problems. Molasses was added to improve the palatability of gin trash. The equation P$d$ = P$a$ -1.25(P$gt$ + $Pde$ + $Pt$ + P$p$) was used to determine the price differential between pelletized gin trash and alfalfa, where P$d$ = price discrimination $Pa$ = price of alfalfa, 1.25 = ANEW, P$gt$ = price of gin trash per ton, P$de$ = price of digestion enhancer per ton of gin trash, P$t$ = cost of cleaning, grinding, and hauling, and P$p$ = the cost of pelleting. The results showed that producers preferred alfalfa when Radex® was held constant at $4 per ton of gin trash and the price of gin trash varied and rises above $55 per ton. However, producers preferred pelletized gin trash over alfalfa when the price of gin trash held constant at $2 per ton and the price of Radex® varied. Under this condition a producer paid as much as $55 per ton for Radex® to treat one ton of gin trash.

The cost saving to the feed lots using loose treated gin trash was estimated to be $39,755,000. This figure represented a cost saving of $7.95 per head during a 120 day feeding cycle. Producers using pelletized gin trash saved $32,260,000 annually. This represented a cost savings of $6.45 per head on a 120 day feeding cycle. The ginning industry also benefited from Radex® as well. Gins would no longer have to pay for the disposal of gin trash and could sell the gin trash, thus bringing in a revenue of $9,000,000 to the Texas High Plains. This estimate was assuming that a volume of 1,800,000 tons of gin trash and a selling price of $5 per ton (the current disposal price of gin trash). Under these conditions, industries that dealt with gin trash would have benefited greatly with the addition of Radex®. Future studies should include a detailed economic analysis for the entire state of Texas and should determine the most economically beneficial sites to produce treated gin trash to be used by feedlots. Future studies should also include a cost comparison to other roughage's commonly used in the Texas cattle industry.

Lalor, et al. (1977) investigated the use of gin trash as ruminant feed. The objective of this study was to determine the feasibility of feeding gin trash to ruminants. Several feedlots, universities, experiment stations, and USDA agencies were used in a survey concerning several aspects concerning gin trash. The results of the survey showed that nutritional values vary depending mainly on the location where the cotton is grown and the weather conditions during ginning and harvesting. The most variable component was the ash content in gin trash. Ash contents ranged from 8 to 28 percent. Cotton that was salvaged from the soil and cotton from areas with blowing soil had the highest ash levels. Protein levels were also found to be in direct relation with the amount of immature cotton seed in the gin trash. The level of seed depended primarily on weather conditions during the growing season and frost at harvest time. Gin trash was also found to be a bulky, low density material that is expensive to transport and difficult to handle. Pelleted gin trash has ten times the bulk density of gin run trash. The pelleted form of gin trash is often shipped 400 or more miles from the point of origin. Cubed gin trash has a higher moisture content as compared to other forms of gin trash.

The feeding of gin trash to ruminants was found to have moderate protein and energy levels and promoted optimum digestive conditions in ruminants. Gin trash can be feed at the growing stages up to 40 percent of the ration before palatability becomes an issue. However, Texas High Plains feed lots reported using gin trash as 90 percent of the feed ration without palatability problems. Further, some of these feedlots reported that they have been using gin trash in feed operations for over a decade. The results of this study showed that palatability was a major concern in the use of gin trash as a ruminant feed. Fields that use arsenic as a desiccant or herbicide was also a major concern of feeding gin trash to ruminants. Some farm chemicals can produce gin trash that would be toxic if consumed by ruminants. Storage of gin trash was also a concern. It was found that the high moisture content and poor storage in some forms of gin trash, especially cubed gin trash, could lead to spoilage and molding, that produces alflatoxin at levels that could be deleterious to ruminants. More investigation needs to be done concerning the effect of chemicals that exist in gin trash and their effect on ruminants.

Lalor, et al. reported that chemical free gin trash made up 500 pounds of a stripper harvested bale of cotton, that was suitable to use as a feed ration. Spindle picked cotton was found to produce 150 pounds per bale. Feed lots were reported to pay $35 per ton, F.O.B., in Lubbock for pelleted gin trash. This gin trash was also shipped at distances of 400 or more miles away for $30 to $35 per ton F.O.B. point of origin. Ground up gin trash brought $28 per ton for local use.

It was sufficiently shown that gin trash does have a place as a feed ration in ruminants. Future studies should investigate the use of other additives that could increase the feed value for gin trash. Future studies should also include the producer cost of cleaning gin trash and processing and handling cost. A study should also show the financial feasibility of using gin trash in relation to other feed rations, and the optimum levels of gin trash to use in feed rations.

### *Summary*

Gin trash can be successfully used in the livestock industry. Gin trash when used as an alternative feed source can reduce cost to the producer while maintaining acceptable nutritional levels to the livestock. Gibson et al. (1995) showed that the addition of Radex® increased the digestibility of gin trash in cattle. They also demonstrated that pelleting with the addition of molasses greatly increased gin trash's palatability and that pelleting made gin trash much easier to handle. Whiting and Schuh (1988) further reinforced this by adding that cubing and screening could eliminate the handling problems related to loose gin trash. Whiting and Schuh stated that gin trash reduced cost when gin trash was used as an alternative feed. Kabala's study showed that gin trash when used as a silage additive increased nutritional values and intensified growth in Assaf lambs. Lalor et al. also showed that gin trash was useful as a feed supplement for livestock. Lalor et al. pointed out, however, that chemically treated gin trash could be toxic if consumed by livestock and measures should be enforced to ensure the safety of gin trash that is used for livestock. Conner's study exhibited that gin trash not only increased the rate of gain in cattle but also increased the level of cellulose availability.

**Other Uses for Gin Trash**

***Studies Dealing with Physical Characteristics of Gin trash***

Miller, et al. (1975) observed the presence of pesticide residues in gin trash. Increases in stripper harvest methods used in cotton production have increased the amounts of crop residue brought to the gins. Pesticides in gin trash have raised concerns especially concerning the practice of feeding gin trash to livestock. Gin trash was collected from nine locations in Texas during the 1971 growing season. These locations included: Sebastion, College Station, Sugarland, Thrall, Oglesby, Lubbock, Chillicoth, Dorchester, and Pecos. Bins were constructed of red wood and were 4 feet X 4 feet X 8 feet with a center partition to contain a half ton of gin trash. There was a slated floor on one side of the bin with a 1 foot X 1 foot wire cage allowing for aeration. The other side of the bin had a solid floor to minimize drainage and aeration. Five pound samples were collected in plastic bags within a few minutes of the collection of the gin trash. The bins were taken to a storage site where they were soaked with tap water to initiate the composting process. The bins were located outside to allow for the collection of normal rainfall. The samples were spread over brown paper and allowed to air dry at 28 degrees Celsius, with relative humidities that were below 40 percent. The samples were ground and divided, later samples were taken and pesticide levels were compared to the original samples.

The results found that preemergence herbicides had the fewest concentrations in the samples that were kept in storage. These level were even lower than samples taken directly from harvest. Chlorinated hydrocarbon insecticides were constant at harvest and during storage. Organophosphorus insecticides decreased during the storage of gin trash from 1 and 2 parts per million to less than 0.1 part per million. Phosphatic-type defoliants averaged 8 parts per million in gin waste at ginning and slowly diminished during subsequent storage. The desiccant paraquat was found in gin waste at ginning and persisted throughout storage. There was no relation between arsenic levels from fields sprayed with arsenic and the arsenic contents of the waste at ginning. However, Arsenic levels increased during composting in the bins. There was no relationship between the amount applied or the number of days between treatment and harvest or the amount of material residues in the gin waste at harvest for Caparol, Cotoran, DEF, Folex, or paraquat.

The results showed that there was a lack of a positive relationship between the rates or times of pesticide application and the quantities of the residues present at ginning. The results also indicated that neither timing nor rate can be used to predict the residue amounts in gin trash at harvest. Residue levels were influenced mainly by weather, growing conditions and the type of harvesting equipment used, rather than the amount of chemicals applied. The use of gin trash in compost should not effect the growth of subsequent crops however, the arsenic from arsenic acid treated fields could inhibit growth in more susceptible plants on certain soils. The presence of pesticides did however, raise social and legal questions. There are no set tolerances for pesticides in gin waste. Therefore, feeding gin trash to livestock with pesticides at any level was not legal.

Anon (1993) examined the use of cotton gin trash as a water treatment. The objective of this study was to determine the feasibility of gin trash as a water treatment aid. Anon evaluated the study performed by Calvin Parnell, Wayne Lepori, and Sergio Capereda. Parnell et al. looked at the conversion of gin trash into activated carbon (AC). The AC produced from gin trash was to be used in the treatment of waste water. The AC was found effective at lowering chemical and biochemical oxygen demanding substances from wastewater. The AC was also shown to remove some metals from wastewater. The typical range for commercial AC iodine ratings is 600 to 1100. The AC generated from gin trash only produced an iodine rating of 200 to 400. This low rating AC from gin trash is less effective in treating pollutants and drinking water. Parnell et al. did however, point out that AC from gin trash only costs 10 percent of the cost of commercially produced activated carbon products. Parnell et al. stated that federal regulatory agencies have been pressuring cities to shift from using chlorine-based treatment technologies to more beneficial methods such as AC from gin trash. Other methods such as AC are not only more economically viable, but also more beneficial to the environment. An increase in the demand for AC would increase the demand for gin trash, which would increase revenue to gins and eliminate the problem of gin trash disposal.

Biblis (1977) performed an experiment on the use of gin trash in building materials. The objective of the study was to determine the feasibility of using gin trash as a fiber board insulation component. Gin wastes were collected from cyclones and mote houses in Alabama gins. The wastes were dried and crushed using a hammer-mill-type animal feed grinder. Southern pine wood particles were mixed with gin waste and other wood fibers in various proportions. The mixtures were dried in a motorized drum mixer and mixed with an 8 percent mixture of Urea-formaldehyde. From each mixture 3, 24 inch X 24 inch board mats were hot pressed at a temperature of 300 degrees Fahrenheit for 5 minutes at 400 psi. Test specimens were taken and tested, according to the American Society for Testing Materials Standards, for flexure strength, internal bond strength, edgewise shear strength, and nail withdrawal on the face.

The results showed that gin trash can be used in fiber board production without wood fibers and still meet commercial requirements. Boards that did include wood fibers, however, exceeded the commercial requirements for fiber board production.

A study should be done in Texas using stripper harvested gin trash to further test the feasibility of using gin trash in building materials. No financial analysis was performed in this study but would prove useful in determining the final cost to producers and the benefits to consumers. A study should also include a value to ginners including processing cost and a market price that cold be determined for gin trash.

Edwards (1994) studied the direct application of waste paper. The problem of an increasing population, extensive soil erosion, and urbanization has raised demand for agricultural cropland. In order for producers to meet this demand they are looking for ways to utilize the productivity of inferior soils. The objective of this study was to determine the effectiveness of gin trash in utilizing inferior soils. Gin trash was applied to the soil annually. The results indicated soil organic matter content on average was increased from 9.5 to 17g per kg after two annual applications of gin trash. The agricultural waste came very clean and ready to use. Edwards did not provide any numerical data to demonstrate the economic feasibility of applying gin trash to agricultural cropland.

Dernovich and Priz (1987) looked at the use of gin trash as a feedstock in the hydrolysis industry. The primary feedstock in hydrolysis plants has been cotton hulls but with the emergence of cotton hulls as a feedstock for cattle, gin trash needed to be looked at as a secondary feedstock. Cotton hulls were compared to gin trash under similar storage conditions. In open storage, gin trash loose not more than 5-10 percent of its absolute dry matter, a weight loss similar in the storage of wood. On the other hand, the qualitative composition of the cotton hulls was significantly impaired which complicated their use in the hydrolysis industry. This result was favorable for gin trash and its possible use in the industry.

*Summary*

Biblis demonstrated that there is a potential for the use of gin trash in the production of fiber boards. Gin trash's wood like composition makes it an acceptable component and meets all safety and health regulations applicable to fiberboard production. Edwards study demonstrated the need for monitoring the level of chemicals in gin trash and that any amount of chemicals in gin trash could be toxic if consumed by livestock. Miller et al. however, contends that there is not a positive correlation between the amount of chemicals used at the time of production and the level of chemicals present in gin trash. Miller et al. Further states that storing gin trash can reduce the level of some of the chemicals found in chemically treated gin trash and that weather, growing conditions and harvesting methods has the greatest influence on the amount of chemicals found in chemically treated cotton gin trash. Anon pointed that gin trash processed into activated carbon was an economically and an environmentally beneficial alternative to treating wastewater.

**Conclusion and Recommendations**

Several potential uses for gin trash have been outlined in this study. The studies outlined were broken into the areas of energy, livestock production, crop production, and other uses. The economic and physical characteristics of gin trash was addressed as well as recommendations for future research projects.

The studies that involved gin trash as an energy source demonstrated a cost savings to gins and energy producers. The incineration of gin trash by gins to dry cotton proved to be an economical and an environmentally sound application of gin trash. Gins that incinerated the gin trash not only received a cost saving by eliminating 85 percent of the normal gas usage but, also eliminated the disposal and environmental concerns associated with gin trash. Gin trash converted in to energy not only reduced energy cost to gins, but also generated revenue when the energy was sold to energy producers.

One problem in using gin trash to produce energy is providing an adequate year round supply. This is due to the seasonal nature of cotton production. The creation of a storage facility that could safely store gin trash for long periods of time would remedy this problem. Another problem associated with using gin trash to produce energy is capital investment and additional regulations that would be required from gins. It would have to be shown that there was an adequate demand for the energy produced by gins to justify the additional expense and regulation.

Gin trash was also found to have tremendous potential as an alternative feed source in livestock production. Gibson et al. (1995) demonstrated that pelleted gin trash provided adequate nutrition to livestock and at the same time generated a cost saving to feedlots and gins. The only problem with pelleted gin trash is finding an adequate number of producers. A study should be done illustrating areas that have the highest potential concerning pelleting and the potential earning that could be received. Whiting and Schuh demonstrated the benefits of using gin trash as a feed supplement for dairy heifers. Research showed that producers preferred pelleted gin trash to loose gin trash, because of the handling and dust problems associated with loose gin trash.

Research in the study also showed that organic compost was also a very popular consideration for gin trash utilization. Gin trash used in compost as illustrated Logsdon (1993), was found to increase soil texture, increase nutritional values, and protect against soilborne and fungal diseases. To be successful as a compost, gin trash must be mechanically aerated. This was usually done with a front end loader. A more economical method of aeration should be determined, that would create a greater cost savings to compost producers and consumers.

Parnell's research demonstrated that gin trash has potential as a compost product. Gin trash used as a compost reduced the amount chemicals needed in plant production. Parnells studies also showed that gin trash could be successfully used in potting soil. It was pointed out that gin trash needed to be thoroughly aerated to assure quality compost.

Other potential uses for gin trash included the use of gin trash in the production of fiber board. Using gin trash in the production of building materials could create a major market for gin trash. Gin trash used in fiberboard production was found to meet industry standards for safety and quality. This would decrease the amount of trees that are cut down annually and provide a cost saving to the construction and ginning industries.

The potential uses for gin trash illustrate its versatility as a cotton by-product. Social concerns over rising fuel cost, chemical usage in crop production, and waste disposal practices will be reduced through gin trash utilization. Gin trash needs more public exposure in order to work successfully as a cotton by-product. At the time there are only a small number of producers that are familiar with gin trash and its potential uses. This is mainly due to gin trash's limited exposure in journals and trade publications.

**Future Research Areas**

There are several research areas that should be considered for the usage of gin trash in the livestock and crop production industries. Future research topics demonstrating the economic benefit of gin trash in crop and livestock production could prove to be beneficial to the crop and livestock industries.

Gin trash has been found to be beneficial when used as a soil builder in crop production. What is not known, however is the economic feasibility of using gin trash as a soil builder in relation to varying crops. The more commonly produced crops produced on the Texas High Plains are cotton, corn, grain sorghum, milo, wheat, peanuts and sugar beets. In order to determine the feasibility of using gin trash to produce these crops, one must determine the optimal amount of gin trash needed to maximize yields in each of the crops listed. Once these amounts have been determined an analysis should be performed determining the economic benefit of using gin trash in relation to other soil amendments.

Future research should also be performed determining the economic feasibility of using pelleted gin trash in the feed supplies of Texas livestock. Texas is a leading producer of cattle, goats, sheep, and horses. Each of these livestock has different feed requirements. before determining the economic benefit of using gin trash in livestock production, the amount of gin trash required to meet the dietary needs of the listed livestock must be determined. Once theses amounts have been determined the economic feasibility of using gin trash in feeding livestock in relation to other feed sources can be determined.

Transportation cost are critical when determining the feasible application of gin trash in livestock and crop production. Most agricultural producers are unwilling to travel long distances for many by-products, if primary products are in close proximity. Transportation cost should be determined for loose and pelleted gin trash. Market coverage must be determined and should include the maximum distance that is economically feasible in order to determine the maximum marketing area for gin trash by-products. Once this has been determined the optimal areas in Texas for distribution can be determined in relation to the livestock and crop production industries.

Pelleted gin trash has presented a great opportunity as a livestock feed supplement. Research should be done in the area of determining the optimal locations in Texas for gin trash pelleting operations. To determine the most beneficial location for pelleting operations, stripper harvested cotton regions should be identified as well as the primary livestock producing areas. Once these regions have been determined the optimal locations can be determined for pelleting operation based on the areas with the greatest supply of gin trash and areas with the greatest demand for pelleted gin trash in livestock feeding. In determining these factors transportation cost and alternative feed cost must be determined.

Another possible research topic would be the economic feasibility of using gin trash in cow-calf, stocker producer, and feedlot operations. These operations have different goals in livestock production and use different feeding methods to obtain these goals. To determine the economic feasibility of using gin trash in each of these operations in relation to other feed supplements, the optimal level of gin trash required to meet the operators' goals must be determined.

Gin trash usage in the horticulture industry is another future research topic that should be considered. Texas has several large horticulture operations that depend on quality compost products to ensure maximum production. Research should be done on the economic benefit of using gin trash compost in relation to other feed sources. Research should include a nutritional analysis in order to determine the amount of gin trash that would be required in relation to other compost products. Findings of the nutritional analysis would prove beneficial in determining the economic benefit of using gin trash compost.

Gin trash compost can be used in the production of several Texas crops. An economic analysis determining the optimal geographic location for gin trash compost operations could prove to be useful to both compost and crop producers. In determining optimal location, applicable crops must be identified as well as stripper harvested cotton regions. Transportation cost should be determined in order to select the optimal location as well as issues of economic and production benefits to crop producers.

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