TESTING OPERATION PARAMETERS OF A THRESHER FOR REMOVAL OF MARIGOLD PETALS

by

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MARIGOLD PETALS

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CHAPTER I

INTRODUCTION

Over the past thirty to forty years, advancements in microbial testing and control, processing procedures, and additives to modify food structure and appearance, have revolutionized the food processing industry. Modern preservation techniques have produced food products that have a much greater shelf life than the same type of food product from the past. Advancements in analytical techniques for inspection and control of microbial populations and chemical contamination have been made to ensure the safety of these food products.

The Food and Drug Administration (FDA) is the governing body in the United States which oversees the safety of food (Hendry and Houghton, 1996). This administration establishes good food manufacturing practices and other production standards such as plant sanitation, packaging requirements, and Hazard Analysis and Critical Control Point programs. It also conducts research on food safety and systematically inspects food production establishments and food warehouses, collecting and analyzing samples for physical, chemical and microbial contamination.

Public concern over food safety by consumers has grown in recent years for a wide variety of reasons. A simplified analysis of these concerns is that modern complex production processes use ingredients, additives and techniques that are not easily understood by the average consumer. The identity and trust of the processor is also lost because food distribution is much broader. Cases of food related illness or fatalities are seemingly indiscriminate as to when and where they occur and the long-term human health effects of some additives are difficult to verify and take considerable time to establish. These health concerns have helped to emphasize the use of natural ingredients.

Food colorants can be found in such food items as canned fruits, candies, and soft drinks. Almost all processed food items contain food colorants. Food colorants are additives used primarily to enhance the color appearance of foods, although some also impart flavor. Visual appeal is the first sensory component, and sometimes the only one, that consumers use in selecting new products and thus food processors use colors to enhance their product's appearance over the competitors.

The public is generally not knowledgeable of the exact ingredients or additives being consumed (Kropf and Houben, 1980). A great concern has developed as to whether artificial food colors are safe for public consumption. Many artificial food colors have been used in the past. Artificial food colors are produced by combining certain chemical compounds. Over the past thirty years, research has shown that chemicals in artificially derived food colorants can cause cancer (Winter 1979). As a consequence, some food colorants have been banned due to their dangerous effects. However, many artificial food colors still remain safe for human consumption.

The economic aspects of using natural colors in place of synthetics tend to be unfavorable (Walford, 1980). The increased processing costs coupled with shorter shelf-life of foodstuffs using natural colorants are deterrents to the use of natural food colors.

The need and desire to replace artificial food colors has placed a greater demand on identifying and developing natural food color. Most natural food colors are pigments that can be derived from biological origins (Hendry and Houghton, 1996.) The more common of these include carotenoids, chlorophylls, anthocyanins, and porphyrins. Chlorophyll is a naturally occurring green pigment that is found in leaves during the summertime. Anthocyanins are a red to purple pigment that develops in leaves during autumn. The pigment is produced after chlorophyll is destroyed. Carotenoids are pigments found in plants that produce an orange or yellow color. They are responsible for the yellow in squash and the orange in carrots. They can also be found in leaves during the fall. Much research has been completed to determine how these naturally occurring compounds affect the color and safety of food products. Some natural food colorants have always and continue to be used by food industries because they produce qualities in the foods that cannot be easily mimicked by artificial food colors. An example is the use of marigold petal meal by the poultry industry.

Marigold petals contain the yellow pigment xanthophyll, which is used in chicken diets to produce a more intense coloration of egg yolks and a warm yellow skin color. Dried and ground petals can be feed directly to chickens, or the xanthophyll can be extracted into a concentrated form and added directly into the chicken feed. Research by Scott et al., (1967) has shown that chickens that consume xanthophyll produce egg yolks and broiler skin with a more intense yellow color.

Marigold flowers are grown and harvested in large quantities because of their high concentration of xanthophyll. Harvesting techniques are labor intensive and thus production is confined to countries with low labor costs. Some of the steps in marigold production include hand-harvesting, drying, and pelletizing the material into an extractable form (Delgado-Vargas and Paredes-Lopez, 1997). This process creates a diluted form of raw material, containing petals, receptacles, and stems, from which the xanthophyll is extracted. A preferred method would harvest only petal material which would reduce drying costs and possibly extraction costs.

The Biosystems and Agricultural Engineering Department and Horticulture and Landscape Architecture Department at Oklahoma State University have proposed research that will investigate several aspects of automated marigold production and processing. These phases include the mechanical harvesting of the marigold flowers, drying of marigold flowers, removal of dried marigold petals, and processing of petals into a meal suitable for direct animal feeding or extraction.

The purpose of this research was to investigate a mechanism suitable for threshing petals from marigold flowers. A mechanism, based on rolling or scrubbing dried flowers between two moving parallel plates, was built to determine the effects of plate gap and plate speed on threshing effieciency.

CHAPTER II

LITERATURE REVIEW

Food Colors

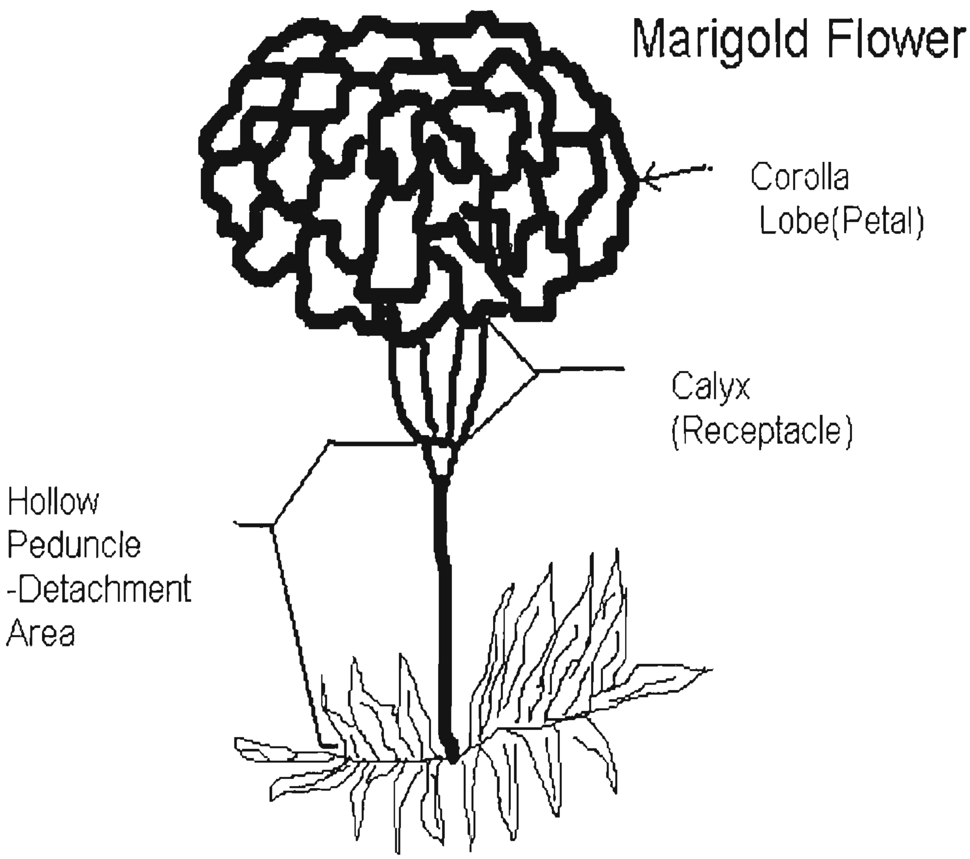
The concern about the risks of artificial food colorings has placed a greater demand on natural food colorants as a substitute. Natural food colorants include carotenoids, chlorophylls, anthocyanins, and porphyrins. Carotenoids are responsible for the red, orange, and yellow colors found in fruits, vegetables, flowers, and fall leaf foliage. Carotenoids are defined into the two groups, carotenes and xanthophylls, McWilliams (1989). Over 400 different carotenoids have been identified, many of which are present in our diets (Hendry and Houghton, 1996). Leaves of nearly all species of plants contain the same amount of carotenoids, β-carotene (25 to 30%), lutein (45%), vioaxanthin (15%), and neoxanthin (15%). Common types of carotenoids include β-carotene, zeaxanthin, canthaxanthin, and xanthophyll (Walford, 1980).

Although nature is abundant with carotenoids there are some disadvantages for their commercial use. Carotenoids are not as stable in chemical structure as that of artificial dyes (Walford, 1980) and are subject to breakdown like many other organic compounds. Carotenoids are sensitive to light, heat, oxidation, and acids and do not offer as great of color range as artificial dyes. The availability of synthetic carotenoids has also decreased the use of natural carotenoids (Phillips and Berry, 1976), although natural carotenoids are still being used in specific areas of the food industry.

Marigold Flowers

Marigold (*Tagetes erecta*) flowers are native to the Central America region. These flowers are annual plants which are easily grown during the summer months. In Central America they are harvested for their yellowish-orange xanthophyll pigment. This pigment is used as a feed supplement by the poultry industry for skin and yolk color development. In the United States, marigolds are mainly used for ornamental purposes, and are commonly found in garden flowerbeds. The size of the flowers depends variety and climate during the growing season. A marigold flower is illustrated in Figure 1. (Still, 1994). The receptacle is the reproductive organ of the marigold flower in which the seeds are found.

Figure 1: Marigold Illustration.



Xanthophyll

Xanthophyll is a carotenoid that is contained in the petals of marigold flowers. This pigment is also found in corn, alfalfa, broccoli, and many other vegetables although the concentration found in these products is not as high as in marigold flowers. Marigold petals may contain from 6 to 10 grams of xanthophyll per kg of dry marigold petals

(Scott, et al., 1967). This is very large compared to 0.55 grams of xanthophyll per kg found in alfalfa. Yellow corn contains much smaller amounts.

Different forms of xanthophyll are present in marigold flowers. Bauernfeind (1981) reported that the petals of *Tagetes erecta* contained 64% lutein, 31% antheraxanthin, and 3.5% α-cryptoxanthin. Lutein is a component of milk and butter and varies in concentration due to the diet of the animal (Bauernfeind, 1981). Lutein is the primary xanthophyll found in the egg yolks of chickens. Antheraxanthin is considered to comprise less than 1% of the total xanthophyll concentration found in egg yolks. α-Cryptoxanthin has been determined to be less effective as a yolk colorant than lutein on a weight ratio basis.

Xanthophyll concentration greatly increases as marigold flowers mature. Gregory et al. (1986) studied the change in concentration of lutein esters of marigold flowers as they matured. Lutein esters were extracted from flowers that ranged from a green-yellow to orange-brown color. By determining the amount of lutein esters in a gram of marigold petals using liquid chromatography, it was found that there was a 200-fold increase in the concentration of lutein between light yellow and dark orange flowers.

Marigold Processing

In today's food industry, marigold flowers are mainly used as a pigment source by the poultry industry. These flowers are processed and placed into chicken feed so that the pigment xanthophyll can be utilized by the chicken. This processing can be completed in different ways. A simple process is to harvest marigold flowers, dry them to a low moisture content and grind them to a course powder. The ground material can then be blended directly into chicken feed.

A second form of processing involves several steps for extracting xanthophyll from marigold flowers. In this process, marigolds are harvested, pressed, and then dried. After the drying process, the marigold material is then ground and pelletized to produce a relatively homogeneous product that can be easily handled. A solvent extraction process is used on the material to produce a xanthophyll extract. The extraction process can use solvents such as n-Propanol, Isopropanol, n-Butanol, *tert*-Butanol, and Ethanol (Phillips and Berry, 1976) to obtain lutein esters from the marigold material. After extraction, it can be placed as an additive into the chicken feed production line.

Xanthophyll Use in the Poultry Industry

Many studies have been made of marigold flower pigments and the effects on poultry. Scott, et al., (1967) found yolk pigmentation is affected by different diets. In their experiments, various standard basal diets were compared to diets supplemented with different amounts of xanthophyll. A basal diet of standard yellow corn and alfalfa meal containing moderate concentrations of xanthophyll pigment was compared with a diet containing marigold petals, having a high concentration of xanthophyll. Measuring the amount of xanthophyll in a given amount of egg yolk completed analyses between the diets. Feed containing the marigold product caused an increase in the amount of xanthophylls in the egg yolks. This, in turn, caused a dark yellowish color in the egg yolk versus a pale yellow color for the standard diet. The amount of xanthophyll in egg yolks was found to reach a limit or plateau, where placing unlimited quantities of xanthophyll in the feed had no further effect. Tyczkowski and Hamilton (1986) stated that the reason for the difference in biological utilization is thought to be that lutein, a dihydroxycarotenoid (DHC) and the main carotenoid in both corn and marigold flowers, occurs primarily as the unesterified free alcohol in corn and as diesters of long-chain fatty acids in marigolds.

Research has also been completed concerning the effects of a xanthophyll on the color of the broiler skin of chickens. It is widely accepted that xanthophyll turns broiler skins and egg yolks a yellow color. The study of the effect of saponified (hydrolyzed) and non-saponified marigold meals conducted by Fletcher and Papa (1986) showed that saponified marigold meals had a greater effect on broiler skin color than non-saponified marigold meals. In this case, a chemical bond in xanthophyll is being broken, and an hydrogen cation is being added. It was concluded that saponification caused an increase in the bioavailability of the carotenoid, but did not greatly affect egg yolk color versus non-saponified marigold meals.

Threshing

Threshers have been developed and used for many agricultural products. Their main purpose is for the removal of a specified plant item from the plant. Threshing mechanisms have been developed to separate peanuts, wheat, barley, soybeans, and other useful agricultural products from unwanted material. This unwanted material could include husks, hulls, leaves, stems, and roots. The goal of this thresher was to remove marigold petals from the receptacles.

The general evaluation of a thresher is normally to determine threshing efficiency. Threshing effieciency is usually based upon measured values of the amount of threshed material, unthreshed material, and trash introduced into the threshed material. Price (1993) examined the threshing efficiency for a stripping rotor thresher for the removal of grain. In the analyses, the threshing efficiency was determined to be the grain separated at the drum divided by the total grain entering the drum, multiplied by 100. Mesquita and Hanna (1996) also used this approach to evaluate a soybean thresher. Chen (1994) discusses research de-stemming oranges. This research deals with a machine that is based on rolling characteristics to remove stems. The machine consisted of a roller conveyor and rotating cutting blades below the conveyor which clipped the stems as they protruded beneath the rollers. Data was analyzed as the percentage of stems removed versus the rotating blade speed and conveyor speed. In general, threshing efficiency ratio can be defined as the threshed material divided by the available material to be threshed.

Objective

The specific objective of this research was to determine the effects of flower moisture content, plate gap height, plate speed, belt speed, and harvest dates on threshing efficiency for an experimental marigold thresher.

CHAPTER III

MATERIALS, EQUIPMENT, AND METHODS

Marigold Flowers

Orange Lady marigolds (*Tagates erecta*) was the specie of marigold flower used for this research. The Horticulture and Landscape Architecture Department at Oklahoma State University planted and cared for these flowers at the Oklahoma Botanical Garden and Nursery complex located in Stillwater, Oklahoma. Marigolds were transplanted in May of 1997. Harvesting of the flowers began in late June and continued through mid-August. Flowers were hand harvested at two week intervals which provided mature marigold flowers on a bi-weekly interval for tests. Mature flowers were randomly harvested throughout the harvest plot during the mid-morning hours to reduce the amount of dew on the flowers. Immature flowers with less than fully developed blooms were left until the next harvest. Any remaining mature flowers were picked and discarded. Picked flowers were placed in polyethelene bags and transported approximately two miles to the Biosystems and Agricultural Engineering laboratory where they were placed in a refrigerated storage at 5°C until threshing tests were conducted.

Equipment

Marigold Dryer

Prior to threshing tests, marigold flowers were dried. A small fixed bed dryer was designed for this purpose in the summer of 1996 by Biosystems and Agricultural engineers at Oklahoma State University. This dryer was housed in a building at Biosystems and Agricultural Engineering Annex.

The dryer was designed for thin and deep bed drying of various biological materials. Air recirculation could be varied down to a total of zero recirculation. A drying rack, constructed from heavy wire mesh, was situated in the middle of the dryer, with respect to the top and bottom of the dryer. The drying bed area was 1.06 m^2. A Dayton 746 Watt belt drive fan and blower motor supplied an air flow of 22.65 m^3/min. to the heater coils at the top of the dryer. The heated air was blown downwards, through the thin bed layer of flowers. For this study, the drying air temperature was set at 65.6 ± 1.7°C for all drying.

Three drying trays were constructed to hold the marigold flowers for thin layer drying. Tray dimensions were 0.86 m. by 0.39 m., and were constructed from 0.25 m. X 0.010 m. wood and 0.0063 m. mesh wire. The wire mesh was stapled to the bottom of the trays. The trays fit side by side in the dryer and covered the entire drying rack area.

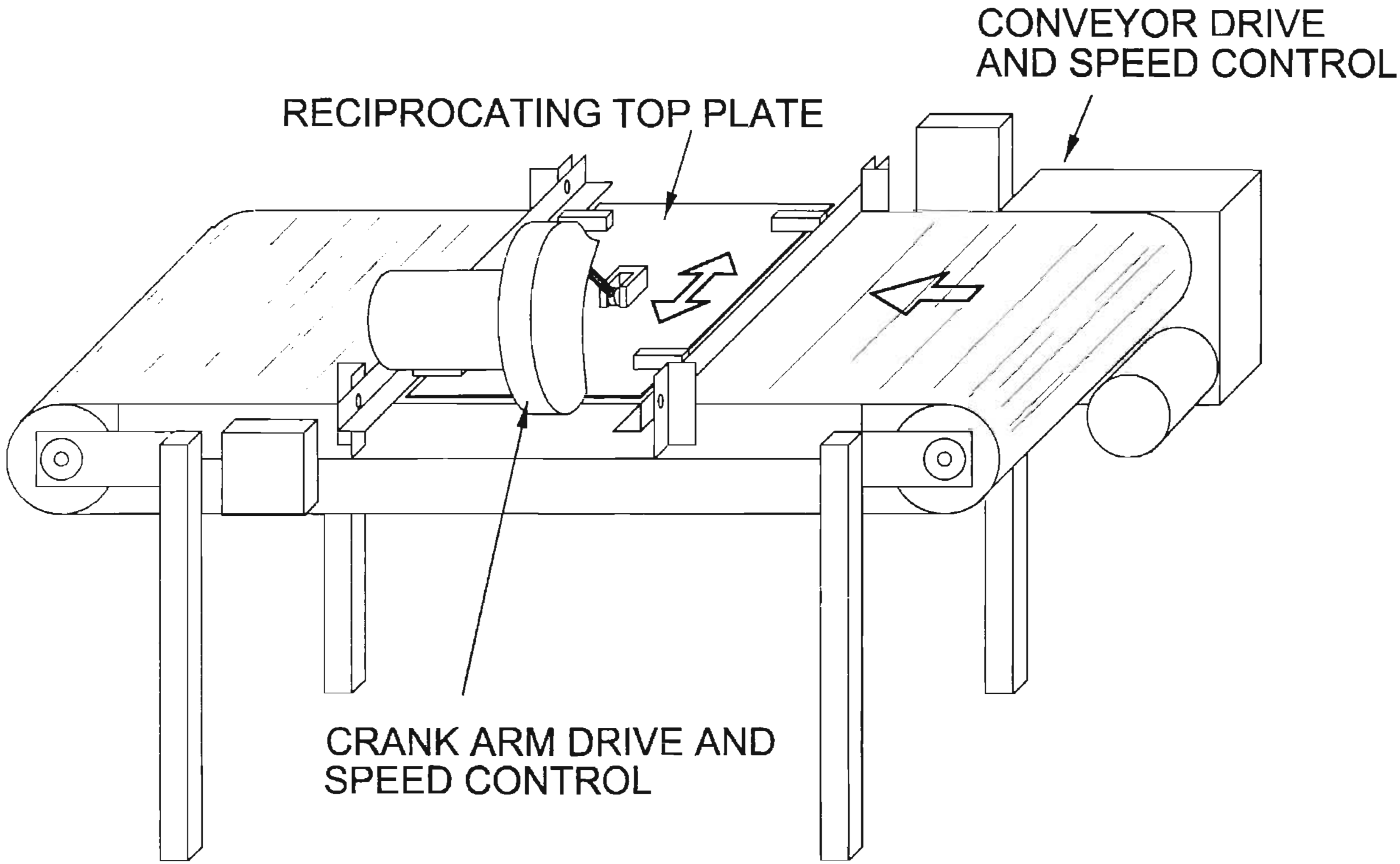
Threshing Mechanism

A thresher was designed and built in the winter months of 1996-97. The threshing action was based on the principle of the human action of scrubbing a dry flower between two hands. With one hand remaining still, the other hand rotates in one direction. A goal of the thresher was to effectively remove petals while limiting damage to the receptacles.

The thresher constructed was a simple two plate system consisting of an endless belt conveyor and an oscillating top plate. The conveyor bottom surface continuously moves in one direction, while the top plate oscillates horizontally and perpendicular to the direction of motion of the bottom conveyor surface. The conveyor feeds flowers into the gap between the plate and conveyor. The gap provides the scrubbing action necessary for effective petal removal. The thresher was designed to accommodate different parameters of plate speed and plate gap width to determine their effect on threshing efficiency. A schematic of the thresher is shown in Figure 2 and engineering drawings in Appendix F.

The conveyor, which forms the bottom scrubbing surface, has a single side surface area of 0.84 m. by 1.42 m. Support rollers (0.13 m. diameter) carry the belt. One roller is driven by a 373 watt variable speed DC motor (Dayton model 2M168D) through a gear reduction drive (Toledo model M56-X, 11:1 ratio) and chain drive. The gear

Figure 2. The Marigold Thresher



reduction drive ratio is 11:1 and the chain drive ratio is 1:1. A motor speed controller (Dart Inc.model 253G-200E) controls the speed of the conveyor. The motor/gear drive is attached to a bracket which is bolted to braces supporting the legs of the conveyor.

The conveyor belting material is 120# tan 2-ply SBR Diamond Top (IBT, Inc.). The belting has a laminated, three dimensional diamond pattern formed on its surface. The belt thickness is 7 mm. The diamond pattern is cut into the belt to a depth of 3.8 mm. The inside length and width of each diamond is 22 mm by 10 mm. The laminate is made of a soft foam rubber that easily deforms when pressed and easily reforms to its original shape after pressure is released. The softness was thought to aid in the threshing process by allowing some deformation to occur when larger flower receptacles pass through the thresher.

The conveyor support structure is a basic table design constructed from steel angle and square tubing. The dimensions of the table are 1.17 m long by 0.88 m wide. Steel angle (0.076 m.) is used as the main support for the rollers. The width of the table is supported by 25 mm steel angle. The legs of the conveyor are made from 38 mm steel angle. 127 mm diameter rollers are used to convey the belt. These two rollers are mounted to 6.3 mm thick plates, which are attached to the conveyor table. A guide mechanism was constructed from 25 mm steel angle and a combination of roller bearing and sliding guides was used to restrict the movement of the plate in a linear direction. The steel angle acts as a rail system for the movement of the top plate. Top plate movement is perpendicular to the conveyor movement Steel angle support legs were used to attach the guide system to the table. The support legs have slots machined in them at the connection point to the guide mechanism to allow for adjustment of the gap width between the top plate and conveyor.

The top plate reciprocating action was achieved by the use of a crank arm attached between a motor driven wheel (305 mm diameter) and the plate. The wheel is driven by a 373 Watt motor (Dayton model 2M168D) elevated above the plate to allow clearance for the crank arm action. One end of the crank arm is attached at the center of the plate; the other end is attached at a 130 mm offset from the wheel center. A motor speed controller (Dart Inc. model 253G-200E) controls the speed of top plate.

Experimental Plan and Methods

Several critical steps were involved in the experimental procedures to obtain data. These steps included obtaining the flower samples, drying the samples to predetermined moisture contents, threshing the samples, and weighing the threshed material for analysis. Harvesting marigold flowers was the first step in preparation of running tests for this study. Flowers were harvested throughout the week that the tests were run. Thirty flowers were picked for each of the twenty-seven tests conducted for the harvest. The flowers were removed from the plant at the point where the recptacle meets the stem. Nine of the twenty-seven tests were performed in one day; therefore, 270 flowers were needed each day of thresher tests. An additional sixty flowers were harvested each picking day so that the moisture contents of the flowers could be determined before and after drying and to determine flower sizes. In total, 330 flowers were picked each day. All twenty-seven tests were performed in a three day period. A harvest consisted of 990 flowers. All flowers were picked in the morning hours so that they would be ready to dry in the evening. Drying time was used to obtain targeted flower moisture contents and thus it was important that the flowers contained no surface moisture or dew.

Flowers from the daily picking were divided equally into the three drying trays and placed in the dryer. The drying temperature for all tests was 65.6 °C. For each harvest, three moisture contents were needed. High, medium, and low moisture contents of the flowers were essential to perform the tests. The low moisture content was obtained by drying the flowers overnight for sixteen hours. The medium moisture content was obtained by drying for fourteen hours. Finally, the high moisture content was accomplished by drying for twelve hours. Nine threshing tests were performed for each moisture content. After the flowers completed drying for their allotted time, the trays containing the flowers were placed into plastic bags and tied off. This ensured that the flowers didn't absorb any moisture during the transfer to the laboratory.

After drying the flowers, thirty flowers were picked randomly from the three drying trays to determine moisture content. Each flower was placed into an 0.051 m X 0.090 m X 0.038 m aluminum drying pan and oven dried at a temperature of 102°C for twenty-four hours. Pans had been pre-weighed using a digital balance. After drying, flowers were again weighed. Moisture contents were computed (wet-basis) to give an indication of how close the flowers were to their targeted high, medium, or low moisture contents.

Thresher settings were adjusted to predetermined values before tests were run. The conveyor test velocity was defined as the linear belt velocity and was adjusted using the motor speed control. The test top plate velocity was defined as the average plate velocity and was also set using the motor speed control. The top plate velocity was calculated from the plate stroke length and stroke time period, i.e. the average velocity was equal to twice the stroke length divided by the time for one cycle. Plate gap was adjusted to predetermined values by raising or lowering the plate guide mechanism on the support legs.

Preliminary tests included different combinations of plate and conveyor velocities, three plate gaps and three flower moisture contents as shown in Table I. Each moisture content was paired with a plate gap setting. Twenty-five flowers were threshed for each setting and threshing efficiencies evaluated using procedures described below. The amount of trash was not determined for these tests.

Analysis of the threshing results, discussed in Chapter IV, indicated that velocity had no effect on threshing efficiency. Because velocity had no effect, a revised experimental plan was used that eliminated this parameter. The revised plan is shown in

Table I: Plate thresher settings used for preliminary tests.

Conveyor/Plate velocity combinations(mm/sec)	Plate gap widths(mm)	Moisture Content(%wb)
280/280	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6
280/140	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6
560/560	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6
560/280	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6
840/420	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6
840/840	6.5, 9.7, and 12.9	7.8, 9.1, and 9.6

Table II: Experimental plan.

Harvest 1	Harvest 2	Harvest 3	Harvest 4
3 plate gaps low MC 3 replications	3 plate gaps low MC 3 replications	3 plate gaps low MC 3 replications	3 plate gaps low MC 3 replications
3 plate gaps medium MC 3 replications	3 plate gaps medium MC 3 replications	3 plate gaps medium MC 3 replications	3 plate gaps medium MC 3 replications
3 plate gaps high MC 3 replications	3 plate gaps high MC 3 replications	3 plate gaps high MC 3 replications	3 plate gaps high MC 3 replications

Table II. Tests were conducted using all combinations of three plate gaps and three moisture contents. These tests were replicated three times for a total of 27 tests for each harvest. Flowers were obtained from four harvests to assess variation during the season. The plate gaps used were the same as those used previously while the top plate and conveyor velocity were set a 560 mm/s.

For each set of constant test parameters, thirty dried flowers were randomly selected from the three drying trays. Flowers were placed sequentially onto the moving conveyor belt and into the threshing mechanism. The threshed material and leftover receptacle was collected at the end of the conveyor by a collecting tray.

The threshed material and the receptacles were manually separated and placed into pre-weighed drying pans. The pans were immediately weighed and placed into a drying oven (102°C for 24 hr) After drying, the pans were weighed again to determine weights of the dry threshed material, the receptacle, and unthreshed petals.

The unthreshed petals were manually removed from the receptacles and placed into a pre-weighed drying tray. The remaining receptacle was also placed into a pre-weighed drying tray. The trays containing the components of the thirty flowers were placed in the oven for 24 hours, followed by weighing. This was completed to determine the dry weight amount of petals not removed from the receptacles during threshing.

The receptacle trash was then carefully separated from the petal particles. Trash is defined as any unwanted flower material in the threshed petal material. The separation of trash was completed by hand to ensure accurate results when determining the amount of threshed petals. After the trash was separated from the petals, both were placed separately into pre-weighed drying pans and placed into the drying oven for 24 hrs. and weighed. These data were used to compute values for the percent of petals not removed (%PNR), the percent of petals removed (%PR), and percent trash.

CHAPTER IV

RESULTS AND DISCUSSION

Post-threshing data collected during the study for each test (Appendix A) included weight measurements of the petals removed (PR, post-oven and pre-oven drying), the receptacle (post-oven and pre-oven drying), the petals not removed (PNR), and trash. Pre-threshed flower moisture contents (MC) and plate gap width settings are also shown in Appendix A.

The percentage of petals removed (%PR) (or threshing efficiency, TE) is defined as:

$$\%PR = TE = \frac{PR}{PR + PNR} \bullet 100\% \qquad (4.1)$$

The percentage of petals not removed (%PNR) is the mass of petals not removed (PNR) divided by total mass (i.e. PR+PNR).

$$\%PNR = 100 - \%PR \qquad (4.2)$$

Trash mass was used to determine the percentage of trash in the threshed material by the equation 4.3. From Figure 1, trash is defined as any part of the receptacle that is present in the threshed material. This trash includes the seeds and leaf material of the receptacle.

$$\%Trash = \frac{Trash}{PR + Trash} \bullet 100\% \qquad (4.3)$$

These calculated parameters were used as dependent variables to determine the effect of plate gap width and flower moisture content on threshing.

Plate Speed and Belt Speed Effects on Threshing

Initial testing included the parameters of plate speed and belt speed. Three belt speeds, two plate speeds, and three plate gaps were used. Data were obtained for the percent of petals not removed (Appendix B.) Analysis of variance of the %PNR (α=.05) showed that belt and top plate velocity did not affect threshing for a constant plate gap and moisture content. There were differences between plate gaps and moisture contents though. Figure 3 shows the percent of petals removed for the different velocities and plate gaps.

Plate Gap Effects on Threshing

The effects of plate gap on threshing are shown in Figures 4, 5, 6, and 7 for four harvests. The general result is that as plate gap decreases the percentage of petals removed (%PR) and trash increases. A low plate gap tends to come in contact with more petals and create larger forces for threshing. This can also crush part of the receptacle as well, during the removal of petals. Data and visual observation indicate that a high plate gap doesn't effectively remove the dried petals from the center of the flower. However, a high plate gap does minimize trash; most of the threshed material from the high plate gap is petal material. There were a couple of inconsistencies from the basic trend in two of the harvests. In Harvest 2, the percentage of petals removed for the medium gap was slightly greater than the percentage of petals removed for the low gap. Also, the percentage of petals removed for the high gap was greater than the percentage of petals removed for the medium and low plate gaps for Harvest 4. Figure 8 shows the effect of plate gap on %PR for all four harvests.

The percentage of trash introduced in the threshed material due to the plate gap was a concern. All harvests show that as the plate gap decreases, the percentage of trash increases. With lower moisture contents, the difference between the percentage of trash for the different plate gaps increases. This is mainly due to the changes in the amount of trash for the low plate gap. The conclusion is that the plate gap greatly effects the percentage of trash found in the threshed material.

Ideal test conditions would be to have consistent flower sizes between harvests for the determination of the effect of plate gap height on threshing. Inconsistent flower sizes between harvests could make it difficult to determine the plate gap height that results in

Figure 3. Bar graph showing the effects of conveyor and plate velocities on percent of petals removed.

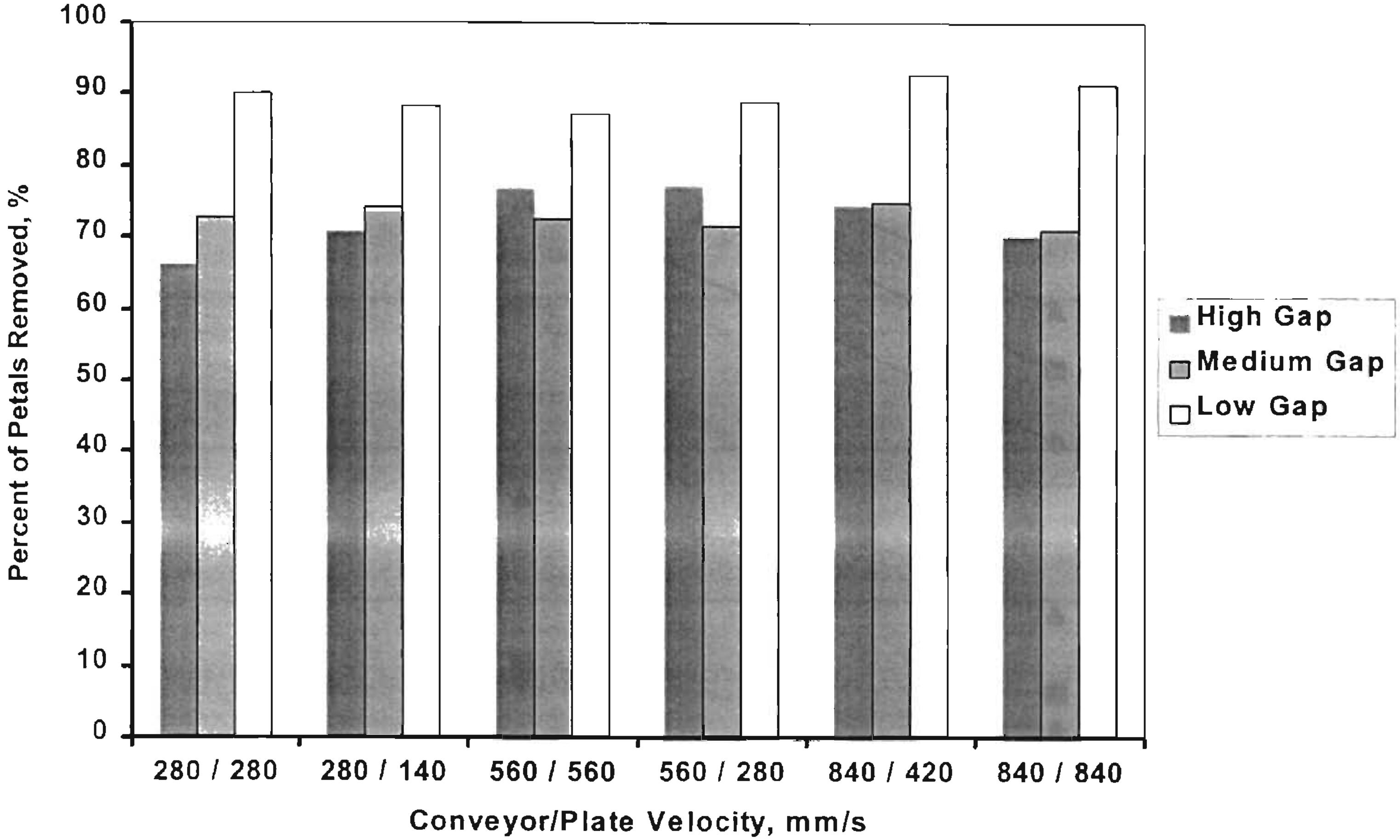


Figure 4. Percent of trash and petals removed (%PR) vs. moisture content for each plate gap for harvest 1. Smooth curve fit through data points. (HG=high gap, MG=medium gap, LG=low gap)

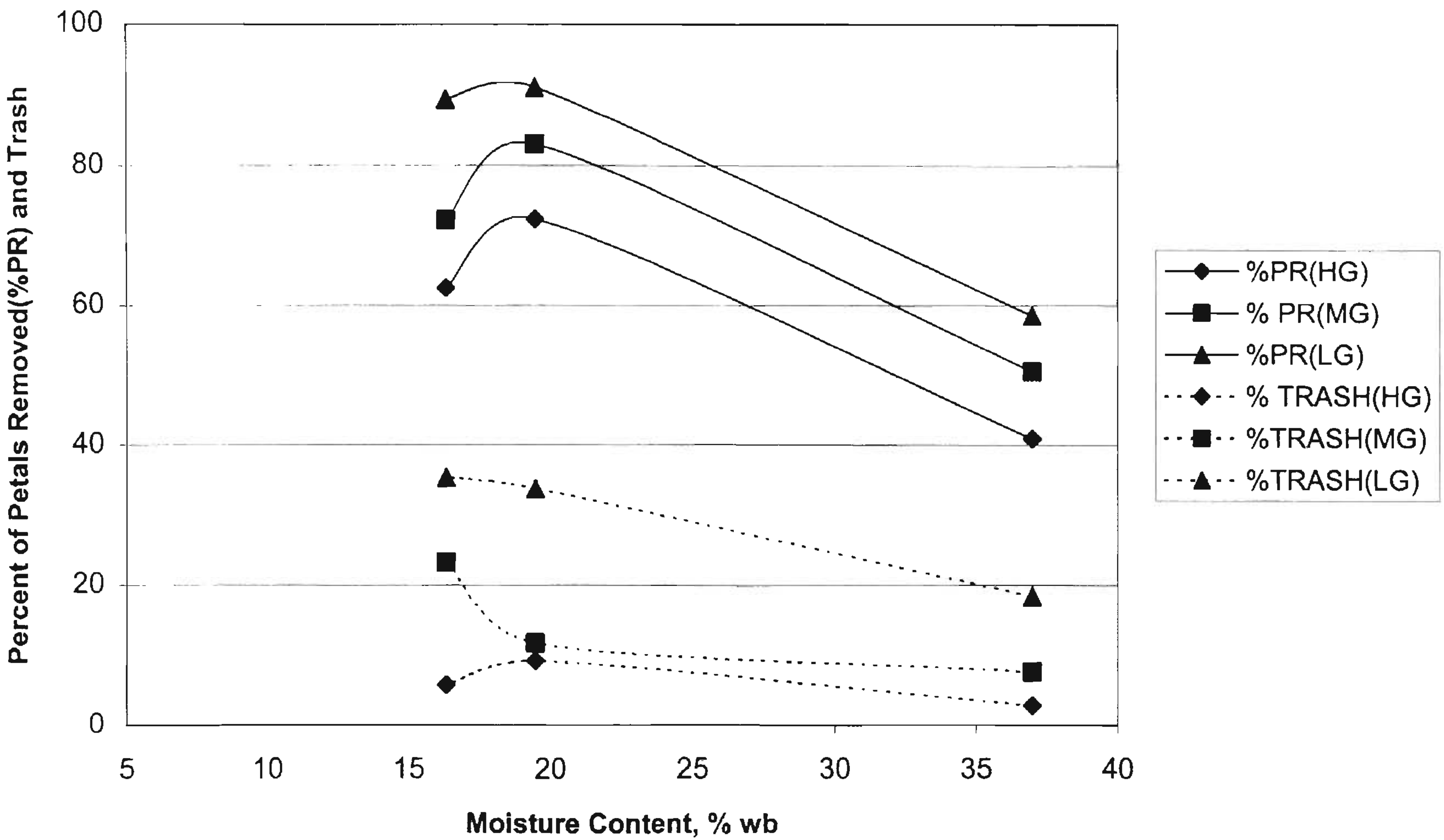


Figure 5. Percent of trash and petals removed (%PR) vs. moisture content for each plate gap for harvest 2. Smooth curve fit through data points. (HG=high gap, MG=medium gap, LG=low gap)

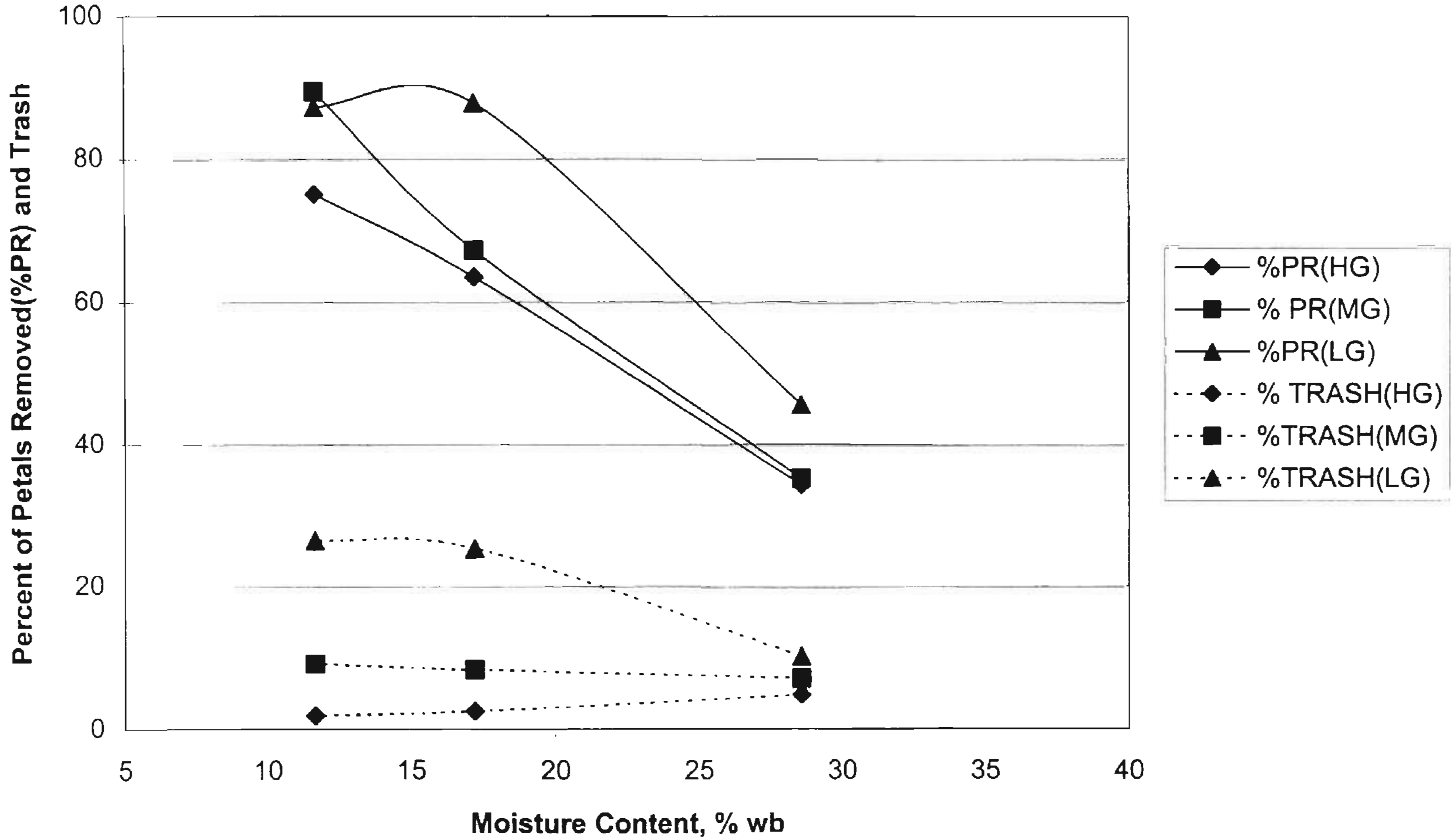


Figure 6. Percent of trash and petals removed (%PR) vs. moisture content for each plate gap for harvest 3. Smooth curve fit through data points. (HG=high gap, MG=medium gap, LG=low gap)

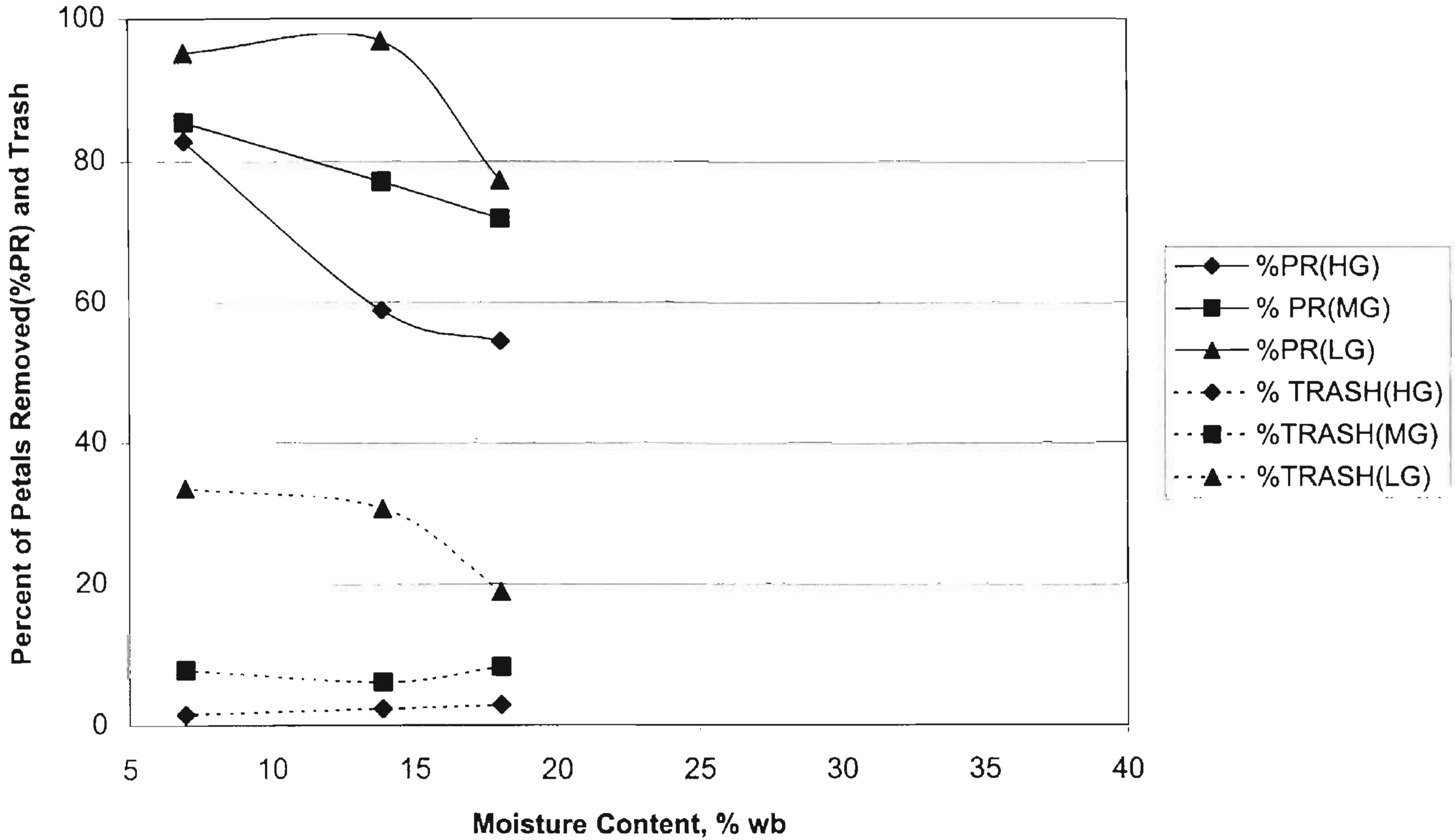


Figure 7. Percent of trash and petals removed (%PR) vs. moisture content for each plate gap for harvest 4. Smooth curve fit through data point. (HG=high gap, MG=medium gap, LG=low gap)

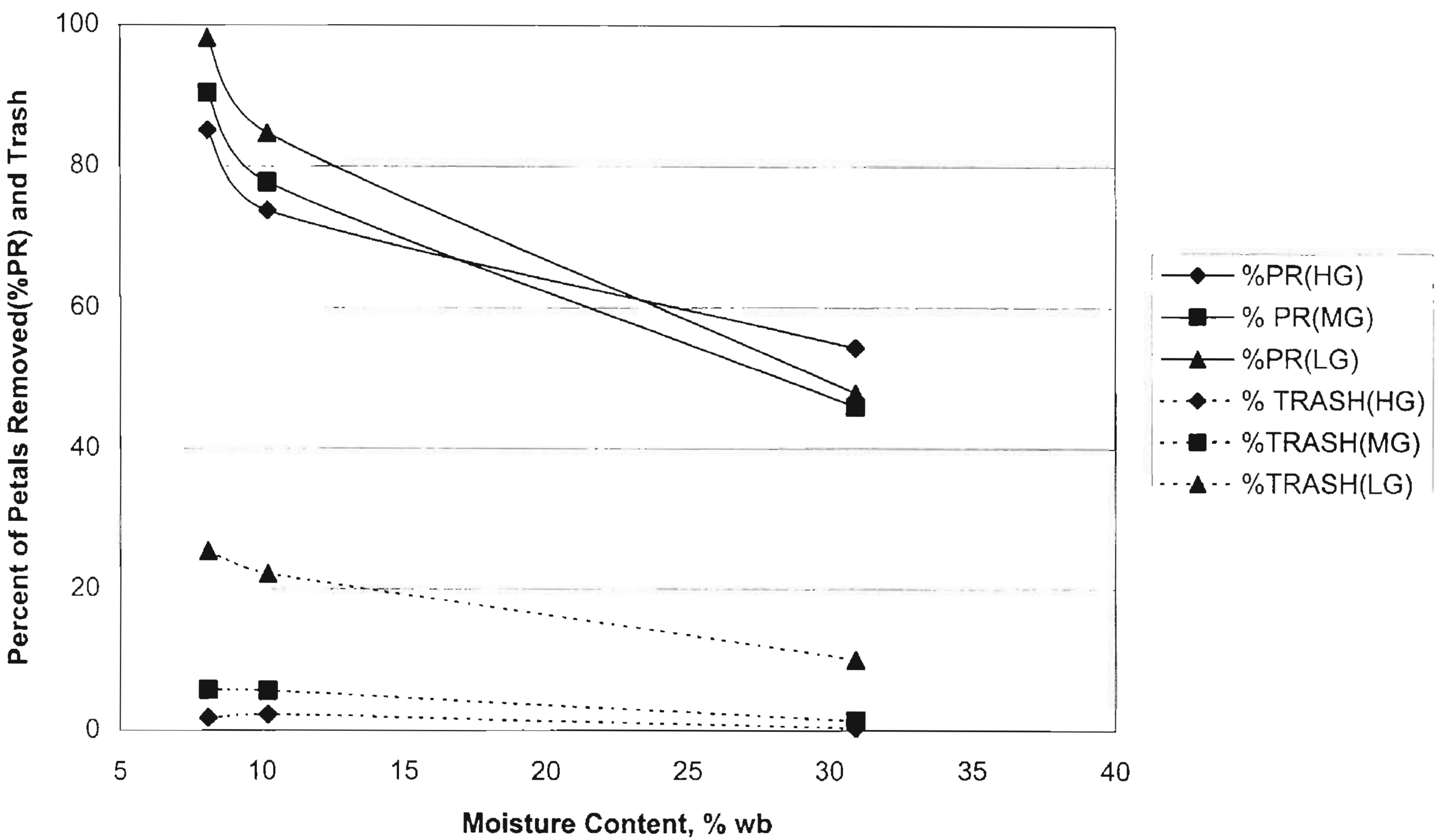
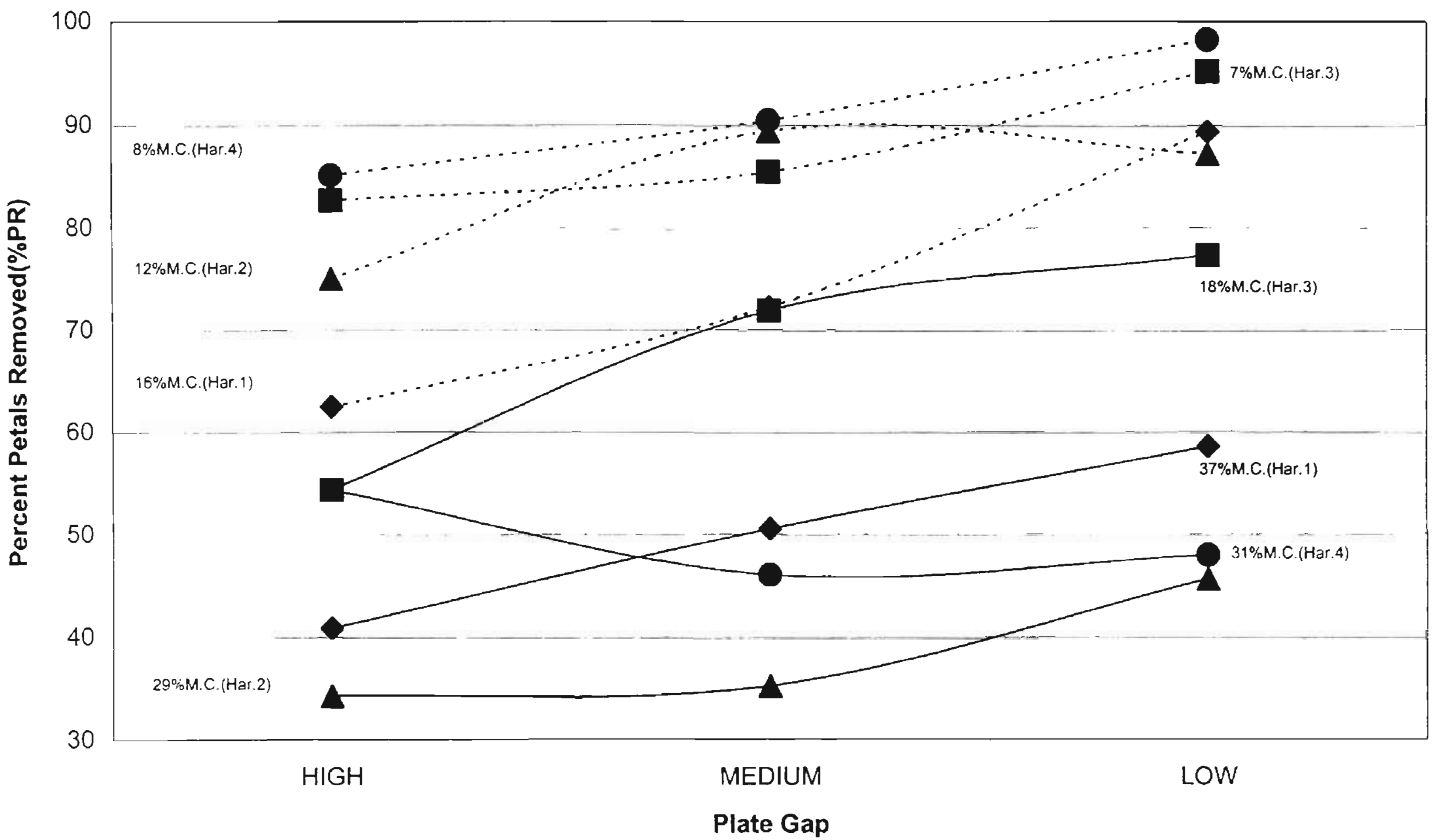


Figure 8. Percent of petals removed (%PR) vs. plate gap height for low and high moisture contents and harvests.



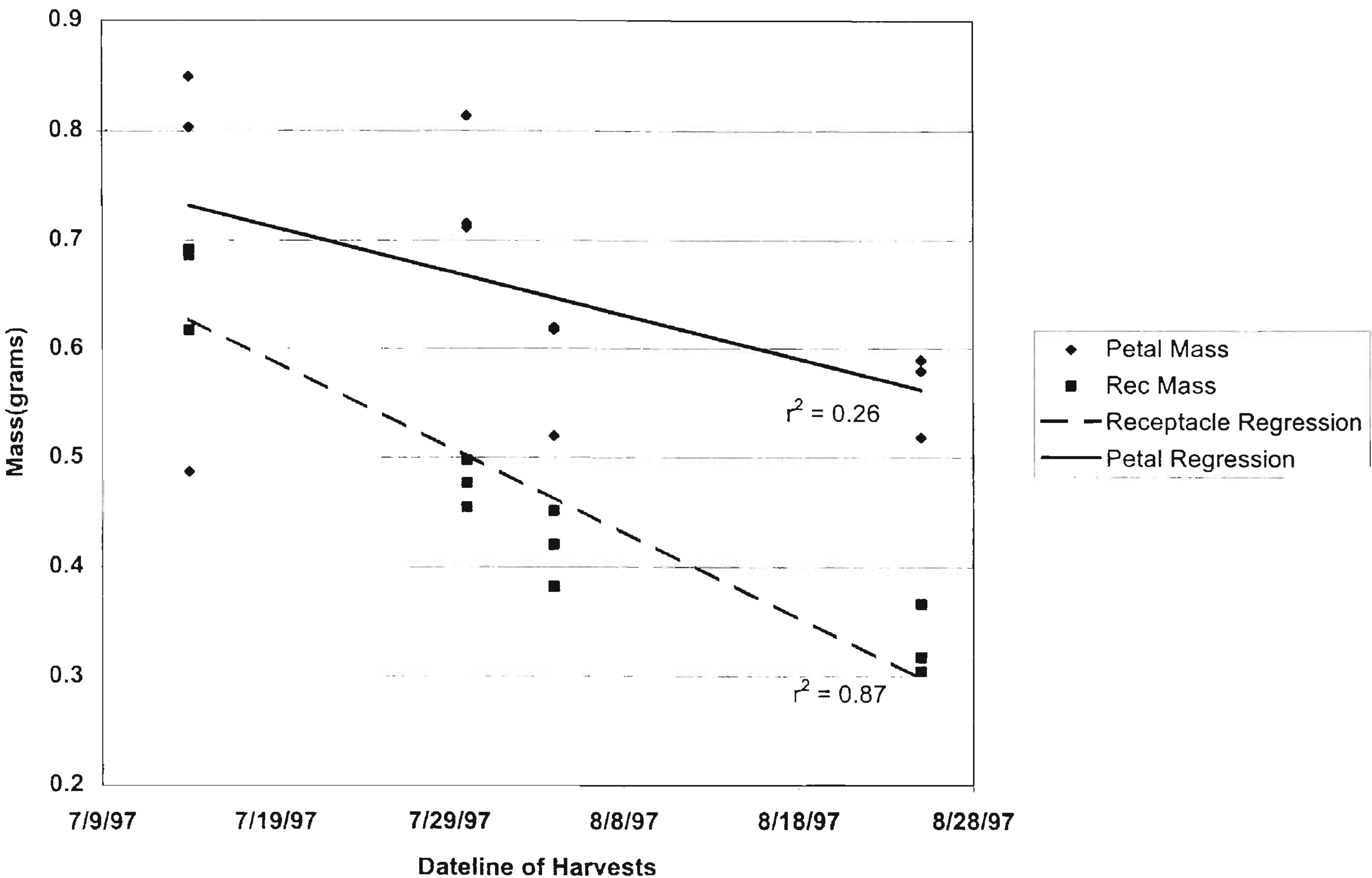
optimal threshing. Receptacle and petal mass were plotted for each harvest (Figure 9.) Each point represents the average weight of 30 flowers randomly selected from the day's test. This data can be found in Appendix C. Results show flower size decreasing with subsequent harvest dates. For example, flower size declined dramatically from early July to late August. Average receptacle mass declined from 0.64 grams to 0.32 grams which is a 50% decline in the size of the receptacle from the first harvest to the fourth harvest. It should be noted that the marigold flowers became infested with worms in the later half of the harvest season and could have had an effect on the flower size. Data concerning the size of the flowers gives a good indication why plate gap width could affect the amount of threshed material between harvests.

Moisture Content Effects on Threshing

The basic trend shows that as moisture content increases, fewer petals are removed except for the low and medium moisture contents of harvest 1 (Figure 4). The percent of petals removed for harvest 1 decreased approximately 31% when the moisture content increased from the medium moisture content to the high moisture content. In harvest 2 (Figure5), there was only one slight inconsistency from the basic trend. The percent of petals removed did not decrease when the moisture content increased from 12% to 17% for the low plate gap. Harvest 3 (Figure 6) showed a good basic trend of percent petals removed decreasing with an increasing moisture content. However, the percent petals removed did not decrease between the low and medium moisture contents for the low plate gap and is likely the result of the moisture difference being small. In harvest 4 (Figure7), the percent petals removed decreased for an increase in moisture content for all plate gaps.

Percent trash in the threshed material was also graphed versus the moisture content of the flowers. These graphs were placed with the graphs of the percent of petals removed (Figures 4-7.) The basic trends of these graphs show that as the percent

Figure 9. Mass of receptacles and petals vs. harvest dates.



moisture content increases the percent trash decreases. This can only be seen for the low plate gap width. As the marigold flowers become drier, more material is removed. This material can be either petal material or trash. In general, there was little difference in the percent of trash found in the threshed material for the high and medium plate gaps for the three moisture contents. Trash was generally around less than 10% for each plate gap. Harvest 1 did have a relatively high trash content in one case for the medium plate gap. For this harvest, the percent trash was determined to be 23% for 16.3% MC for the medium plate gap. The trash declined to around 12% for a 19.4% MC. This is a decline of 11% in the trash percent versus an increase of 3.1% MC. This large decrease in the percent trash for a small change in the percent moisture content is not the general trend of the other harvests. Harvests 2, 3, and 4 show very slight changes in the percent trash based upon the change of percent moisture for the high and medium gap. Moisture content has a greater effect on the amount of trash threshed for a low plate gap setting. These tests did show a decline in trash as the moisture content increased.

Figure 8 shows the effect of percent of petals removed (%PR) vs. plate gap height. The trend shows that as the plate gap height decreases the percent of the petals removed (%PR) increases. The graph also indicates that as moisture content decreases for a given plate gap height, the percent of the petals removed (%PR) increases.

By calculating the percentage of petals not removed, the data gives an indication of the plate gap and moisture content parameters that are not well suited for complete threshing. Figures 10, 11, 12, and 13 show the effects that plate gap height and moisture content have on the percent of petals not removed. These results show that, for a given moisture content, a low plate gap width gives a lower percentage of petals not removed (%PNR) than that of a medium or high plate gap width. The general trend of this data show that as the moisture content decreases, the %PNR also decreases. Figure 10 (Harvest 1) shows an inconsistency in the %PNR between the low and medium moisture contents; the %PNR is greater for the low moisture content than that for the medium

Figure 10. Percent petals not removed vs. moisture content for each plate gap for harvest 1. Smooth curve fit through points. (HG=high gap, MG=medium gap, LG=low gap)

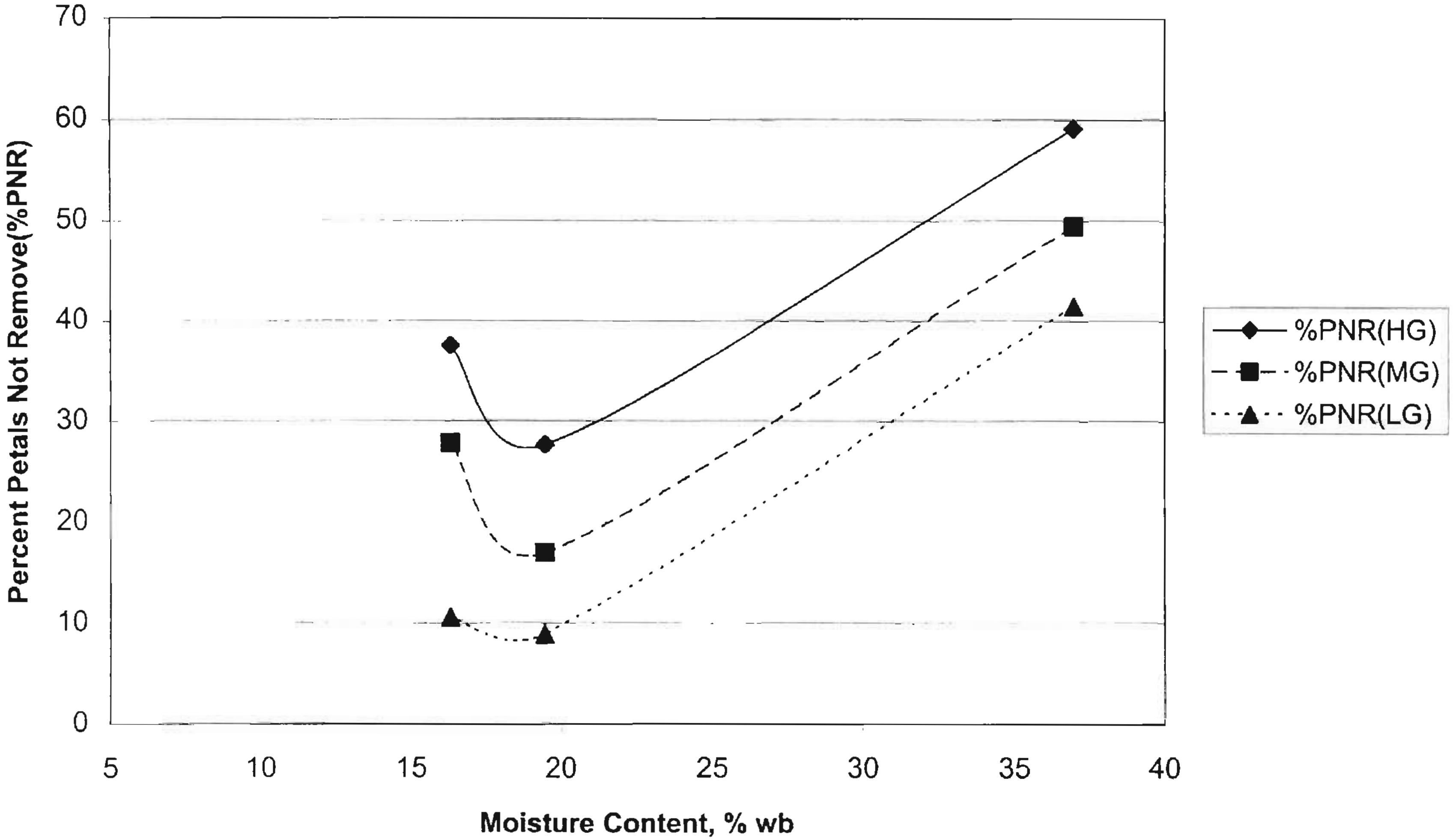


Figure 11. Percent petals not removed vs. moisture content for each plate gap for harvest 2. Smooth curve fit through points. (HG=high gap, MG=medium gap, LG=low gap)

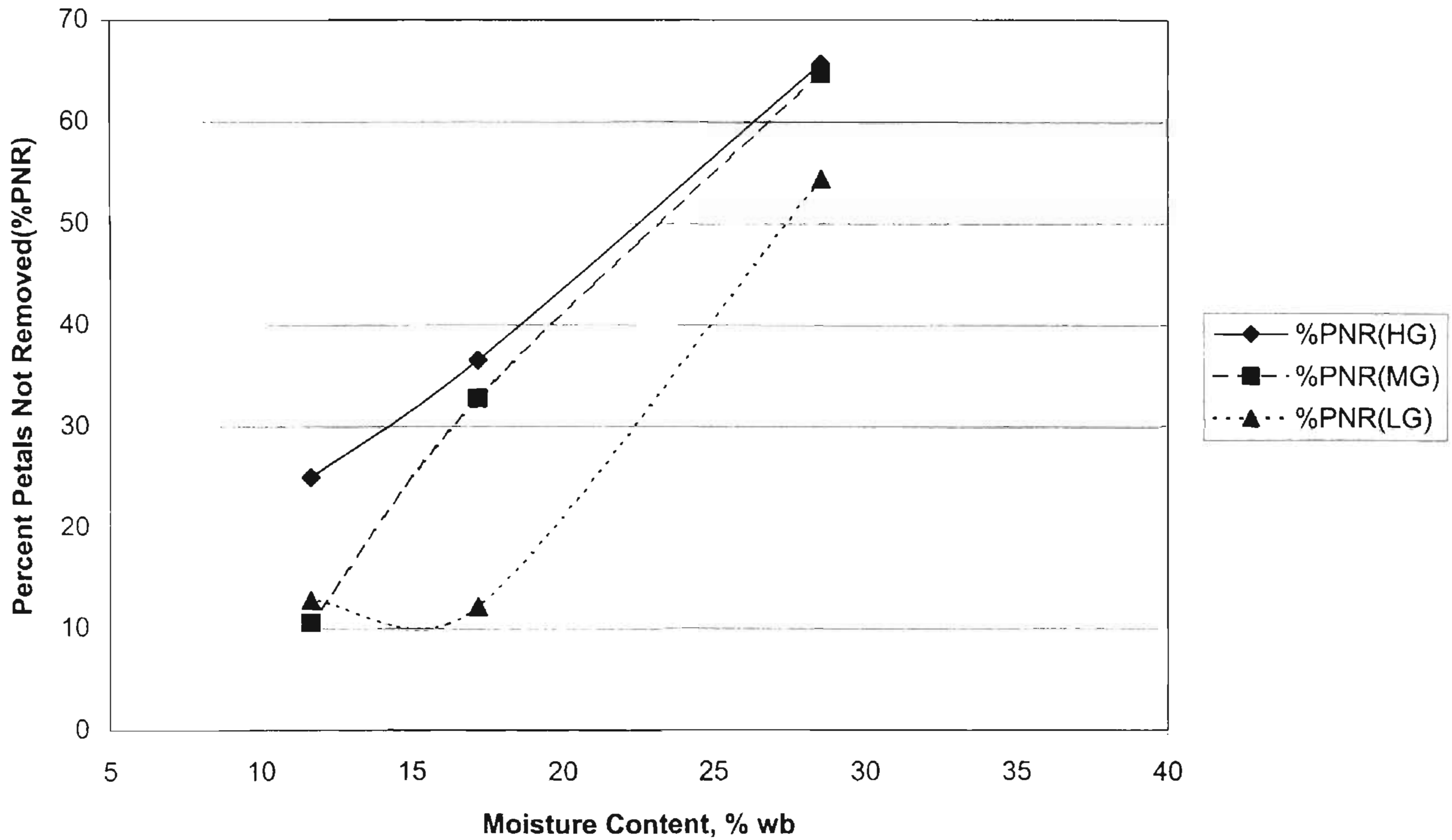


Figure 12. Percent petals not removed vs. moisture content for each plate gap for harvest 3. Smooth curve fit through points. (HG=high gap, MG=medium gap, LG=low gap)

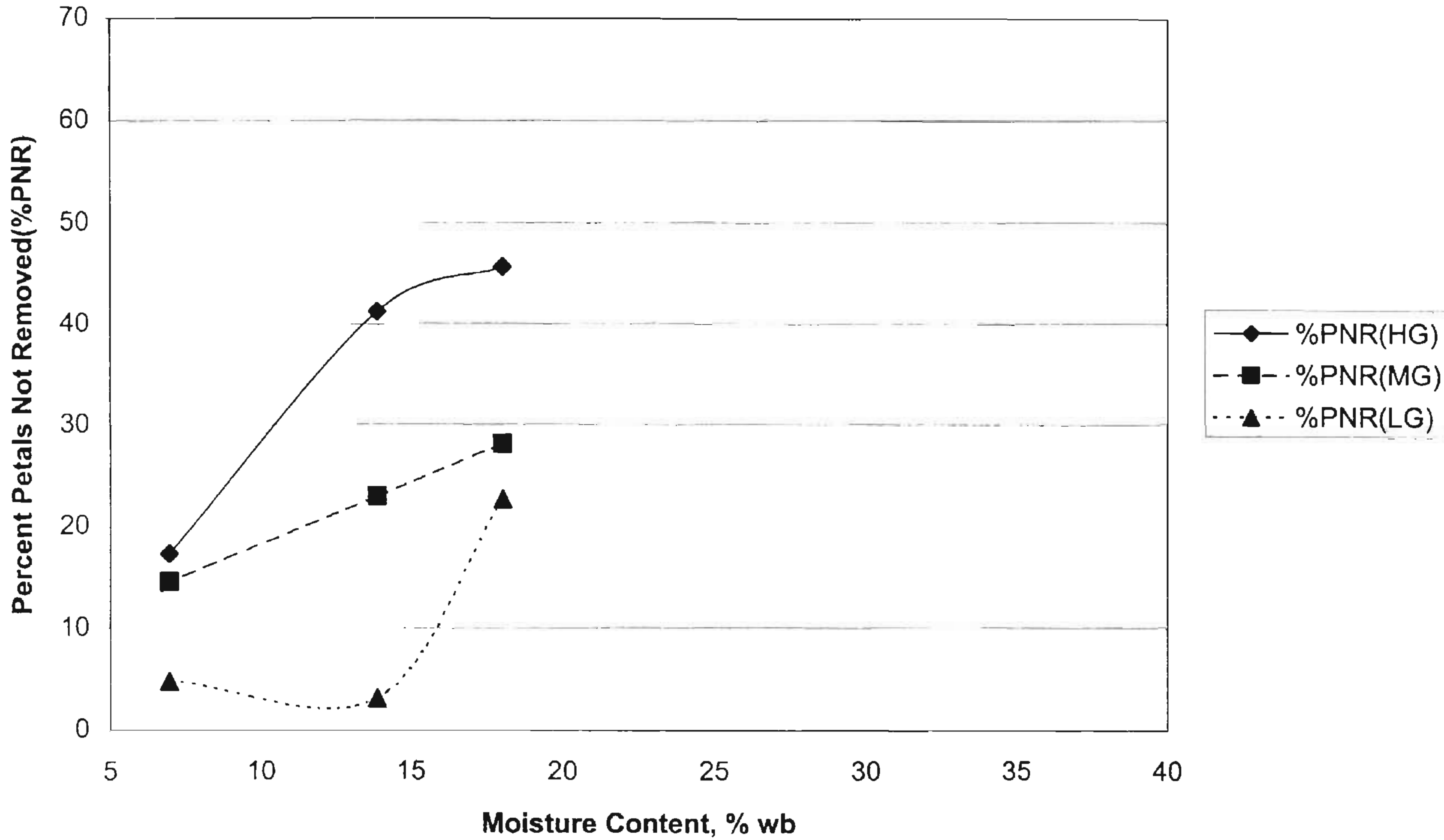
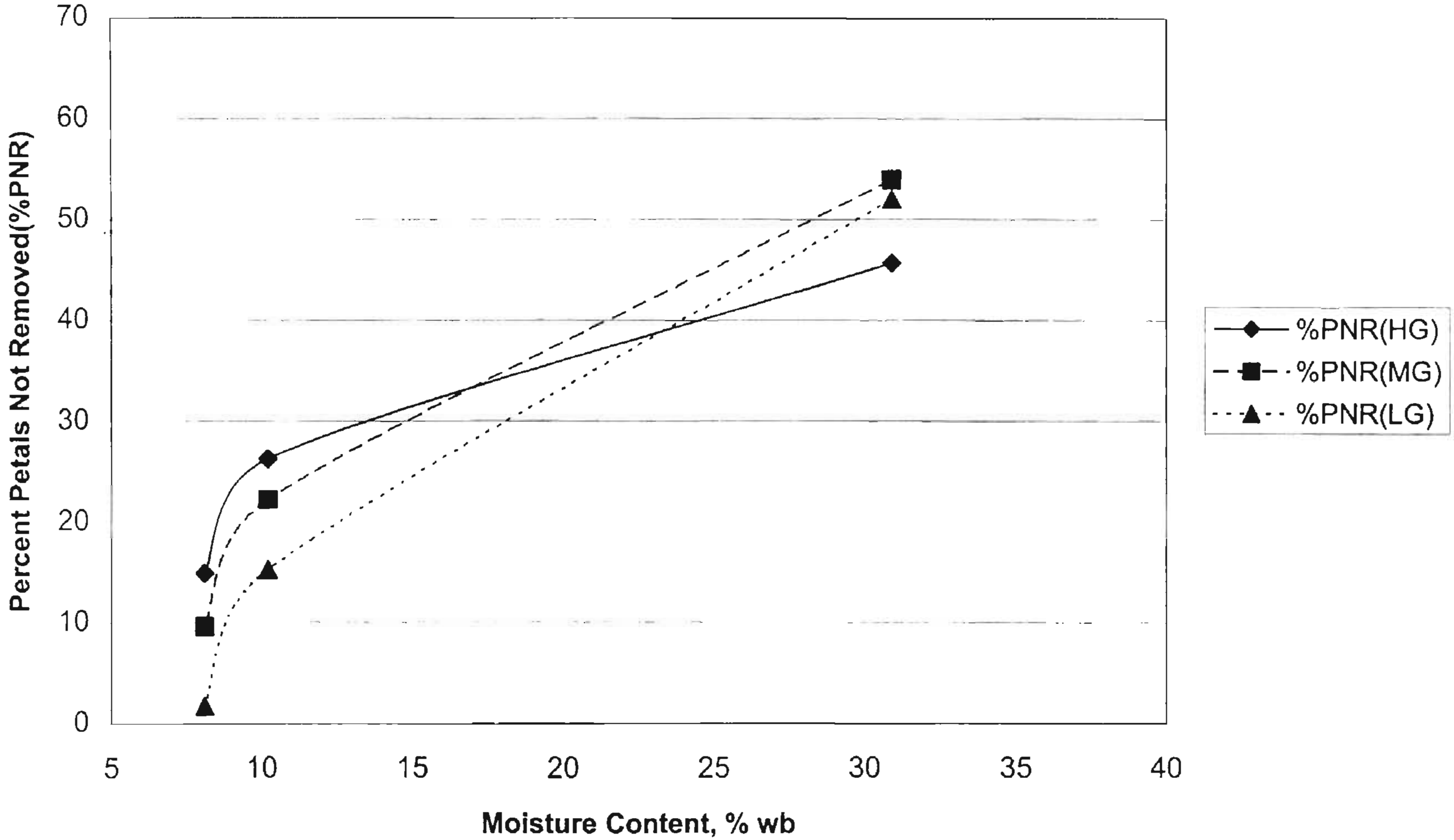


Figure 13. Percent petals not removed vs. moisture content for each plate gap for harvest 4. Smooth curve fit through points. (HG=high gap, MG=medium gap, LG=low gap)



moisture content. An inconsistency also occurred in Figure 12 (Harvest 3) for a high plate gap between the medium and low moisture contents. Both of these are contradictory to the general trend of the graphs. Figure 11 (Harvest 2) showed the expected trend of how threshing is affected by plate gap width and moisture content.

Data were plotted for %PNR vs. moisture content for all four harvests to show the basic trend of plate gap affected by moisture content. Figure 14 shows that as the moisture content increases, %PNR also increases. The data for the %PNR were analyzed for each plate gap. Linear regression of this data gave r-squared values of 0.69, 0.71, and 0.74 for the low, medium, and high plate gaps, respectively. These r-squared values indicate that the %PNR for each plate gap are not well represented by a linear relationships. The target test moisture contents of both the petals and receptacles were examined to determine if the high, medium, and low moisture contents were consistent throughout the harvests. Actual target moisture contents were 10%, 15%, and 25% for low, medium, and high moisture contents. Data were analyzed by separate harvest using single factor analysis of variance and by entire flower population using multiple factor analysis of variance with replication. Both showed strong statistical differences ($P<0.01$) among the grouped data of moisture contents. Duncan's multiple range test was used to rank the means for each analysis and organize the means in ascending order according to statistical difference ($\alpha<0.05$). Tables III and IV indicate statistical differences among moisture contents represented by different letters. Table III shows differences among moisture contents in each harvest based upon petal moisture content and receptacle moisture content. Tables IV shows differences based upon the entire population of flowers. Table III shows that the low and medium moisture contents were statistically the same for Harvest 1 and 4, for the petals. This is confirmed from Harvest 1 and 4, for the receptacles from Table III. Also, the low and medium recptacle moisture contents

Figure 14. Percent petals not removed (%PNR) vs. moisture content for all harvests and plate gaps.

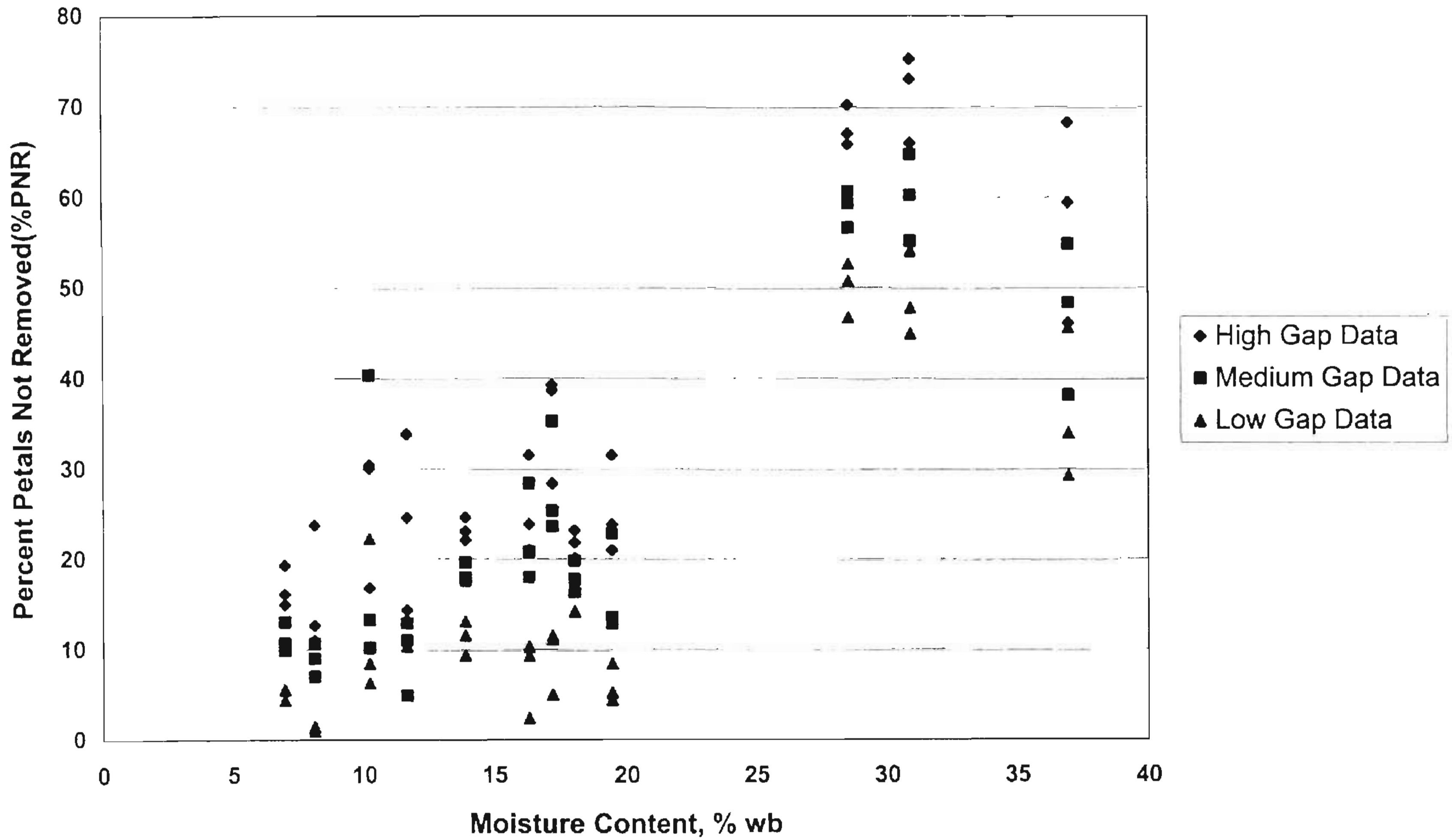


Table III: Means for petal and receptacle moisture contents compare within each harvest.

Harvest #	Target M.C.	Petal M.C.	Receptacle M.C.
1	LOW	14.10a	16.32a
1	MEDIUM	13.57a	19.46a
1	HIGH	29.15b	36.97b
2	LOW	11.65a	12.58a
2	MEDIUM	17.20b	17.29b
2	HIGH	28.60c	27.11c
3	LOW	6.96a	7.75a
3	MEDIUM	13.88b	10.24a
3	HIGH	18.27c	21.97b
4	LOW	8.11a	8.62a
4	MEDIUM	10.21a	12.43a
4	HIGH	30.92b	35.34b

*Means with same letter in a column are not significantly different (Duncans, α=.05)

Table IV: Means for petal and receptacle moisture contents compared between harvests.

Harvest #	Target M.C.	Petal M.C.	Receptacle M.C.
1	LOW	14.10cd	16.32cd
1	MEDIUM	13.57cd	19.46de
1	HIGH	29.15e	36.97g
2	LOW	11.65bc	12.58bc
2	MEDIUM	17.20d	17.29d
2	HIGH	28.60e	27.11f
3	LOW	6.96a	7.75a
3	MEDIUM	13.88cd	10.24ab
3	HIGH	18.27d	21.97e
4	LOW	8.11ab	8.62ab
4	MEDIUM	10.21abc	12.43bc
4	HIGH	30.92e	35.34g

*Means with same letter in a column are not significantly different (Duncans, α=.05) were statistically similar for harvest 3. Table IV shows differences among moisture contents for all groups in the population.

The method of drying for each moisture content was based on time and sensory evaluation by feeling the petals. For the low target moisture content, the flowers were dried 14 hours. The medium and high moisture contents were dried for 12 and 10 hours, respectively. Several factors could have contributed in the differences for each moisture content. Data showed that flower size decreased as the harvest season progressed. Smaller flowers may take less time to dry. The relative humidity of the outdoor air on different drying days could have been a contributing factor. Accumulation of these factors could cause considerable variations in the target moisture contents for each harvest. These variations aren't easily fixed due to the time required to determine the true moisture contents.

Mass data of petals and receptacles from 30 randomly dried flowers for each targeted moisture content of that harvest are located in Appendix D. Also included are the calculated moisture contents for each flower. Means and standard deviations are also located in Appendix D. The standard deviations provide information of the consistency of the moisture contents for each target moisture content in each harvest. For example, Appendix D.1 gives a mean of 36.97% and a standard deviation of 12.35% for the receptacle moisture content. This is a large standard deviation compared to the mean and indicates large variation between individual receptacle moisture contents. The large standard deviations for all target moisture contents show that the values for moisture content were widely variable. Coefficients of variation were also calculated. These values show how the standard deviation values among different groups of data relate to each other. For example, for the high moisture content of harvest 1, the coefficients of variation for the receptacle and petal moisture contents are 0.33 and 0.40. Since the petal's coefficient of variation is greater, then there was more variation in the moisture contents of the petals than the receptacles. There was not a basic trend among the coefficient of variations. Half of the coefficient of variation values for petals were higher than the receptacle values. The coefficient of variations ranged as follows: harvest 1, 0.33-0.53; harvest 2, 0.19-0.50; harvest 3, 0.36-0.58; and harvest 4, 0.24-0.95. Harvest 4 shows a wide range of coefficient of variation values.

Statistical Analysis of Moisture Content and Plate Gap Height

It is important to determine if plate gap height and moisture content have a significant effect on the %PR. Steel(et al.,1997) calls this measurement of the degree of association between multiple variables a multiple correlation. The multiple linear equation is given as:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 \tag{4.3}$$

The importance of a variable in a multiple regression equation depends on what the other variables are included in the equation. In this case, it is important to determine if the variable plate gap height is significant. It is also important to test if the variable of moisture content is significant in nature. In the equation, Y represents the estimated value of percent petals removed and β_o represents the y-intercept of the equation. X_1 and X_2 are the moisture content and plate gap height variables. β_1 is the slope of the equation due to the moisture content effects, and β_2 is the slope due to the plate gap height. T-tests were performed to test a null hypothesis that these slopes were equal to zero. These values were calculated using the multiple regression analysis in the Microsoft Excel data analysis toolpack. According to the t values obtained for each harvest(Appendix E), all null hypothesis' were rejected and concludes that the effects due to moisture content and plate gap height were significant. Combined p-values were below the 5% significance level. From Appendix E, r^2 values ranged from 0.87 to 0.95. Individual p-values were also calculated to show if one varible is more significant than the other. For instance, in harvests 1, 2, and 4, the p-value for plate gap is higher than the p-value for moisture content, indicating that the effect due to moisture content was greater than the effect due to plate gap height. Harvest 3 showed an opposite effect.

CHAPTER V

Summary and Conclusions

The plate thresher was effective for removal of up to 98% of the petals. In some cases only 36% of the petals were removed. Threshing characteristics of the plate thresher were found to depend on petal moisture content, plate gap width, and harvest date.

Data showed that as flower moisture content decreases, the percentage of petal material removed from the flowers increases, for all harvests. Data also showed that as flower moisture content decreases, the amount of trash material in the threshed material increases for the medium and low plate gaps, but not for the high plate gap.

Plate gap width affected the percentage of threshed petals removed and trash in the threshed material. Lower plate gap widths increased the percentage of petals removed and percentage of trash for all harvests.

The linear relationships found between the percent of petals removed (%PR), plate gaps, and moisture contents (multiple linear regression), for combined harvest data, were reasonably good (r^2=0.87 to 0.95). Both plate gap and moisture content are significant parameters in estimating the percent of petals removed ($P<0.05$.)

Variation of threshing results between harvest may be attributed to the difference in flower size. Receptacle and petal mass decreased for each subsequent harvest period. The difference in receptacle and petal mass between the first and fourth harvest was approximately 50%. Moisture content of the fresh flowers were consistent throughout the harvests.

CHAPTER VI

RECOMMENDATIONS FOR FUTURE STUDY

Threshing efficiencies of the plate thresher need to be improved and coupled with a reduction in the amount of trash threshed. Two potential improvements would be to use different belting materials and the adjustment of the plate gap to correspond to the flower size. A thicker and softer belting material that would deform around the receptacle but still cause petal threshing may improve threshing efficiency. Adjustment of plate gap based on average flower size may minimize the trash being threshed.

Flowers at high moisture contents were less suitable for petal removal by this method than flowers at low moisture contents. Additional studies using this method should examine lower petal moisture contents at least below 20% wet basis.

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APPENDIX

Appendix A.1

Harvest 1 data for threshing of marigold flowers at three different moisture contents and three adjustments in plate gap height.

			After Drying and Threshing Period		After Oven Drying			
Test Number	Target Moisture Content	Plate Gap Height	Material Removed Weight(grams)	Receptacle Weight(grams)	Material Removed Weight(grams)	Receptacle Weight(grams)	Petals Not Removed(grams)	Percent Petals Not Removed(%)
1	HIGH	HIGH	28.04	40.46	26.88	33.17	5.94	68.23
2	HIGH	HIGH	29.57	40.23	28.20	33.66	5.40	59.42
3	HIGH	HIGH	30.01	50.15	28.57	38.46	9.49	46.05
4	HIGH	MED	30.94	34.04	29.48	28.95	3.37	54.82
5	HIGH	MED	34.52	31.75	32.80	26.84	3.68	48.30
6	HIGH	MED	29.07	43.46	27.74	34.45	5.85	38.09
7	HIGH	LOW	38.73	23.65	36.50	19.48	1.58	45.56
8	HIGH	LOW	38.43	21.13	36.45	18.20	1.31	33.95
9	HIGH	LOW	41.34	28.76	38.69	22.32	2.83	29.23
10	MED	HIGH	15.67	69.56	15.10	45.61	15.55	23.82
11	MED	HIGH	18.58	75.50	17.84	49.37	14.62	20.96
12	MED	HIGH	21.78	57.39	20.81	41.97	11.04	31.43
13	MED	MED	22.94	72.56	21.67	46.40	16.76	13.48
14	MED	MED	25.19	72.09	23.81	49.02	14.98	12.81
15	MED	MED	24.08	57.35	22.95	39.61	9.24	22.81
16	MED	LOW	26.12	77.65	24.51	47.30	13.97	5.22
17	MED	LOW	30.94	66.70	28.91	42.53	10.84	4.39
18	MED	LOW	35.99	53.98	33.75	37.41	10.70	8.39
19	LOW	HIGH	24.42	53.17	23.37	44.10	13.05	45.69
20	LOW	HIGH	29.03	44.01	27.65	38.86	8.55	30.16
21	LOW	HIGH	28.19	44.79	27.00	39.45	8.99	31.98
22	LOW	MED	41.19	38.30	38.55	31.50	6.72	17.96
23	LOW	MED	35.00	37.96	33.02	32.23	6.61	20.75
24	LOW	MED	32.33	46.83	30.34	38.78	8.87	28.36
25	LOW	LOW	65.40	18.04	61.76	15.88	1.15	2.43
26	LOW	LOW	47.31	26.38	44.52	22.21	3.77	9.30
27	LOW	LOW	47.56	29.78	44.50	24.18	4.20	10.28

Appendix A.2

Harvest 2 data for threshing of marigold flowers at three different moisture contents and three adjustments in plate gap height.

			After Drying and Threshing Period		After Oven Drying			
Test Number	Target Moisture Content	Plate Gap Height	Material Removed Weight(grams)	Receptacle Weight(grams)	Material Removed Weight(grams)	Receptacle Weight(grams)	Petals Not Removed(grams)	Percent Petals Not Removed(%)
1	HIGH	HIGH	10.13	49.29	9.46	32.67	19.19	68.54
2	HIGH	HIGH	10.87	46.74	10.13	31.92	19.49	67.91
3	HIGH	HIGH	8.88	51.37	8.27	33.66	19.44	60.71
4	HIGH	MED	14.75	54.22	13.65	35.48	21.07	73.06
5	HIGH	MED	15.28	46.95	13.75	29.47	17.91	58.99
6	HIGH	MED	15.30	51.44	14.05	32.30	20.44	62.32
7	HIGH	LOW	22.16	45.47	20.07	27.69	17.58	50.93
8	HIGH	LOW	20.31	51.68	18.49	30.40	19.03	54.80
9	HIGH	LOW	19.53	49.16	17.75	30.71	19.72	57.45
10	MED	HIGH	21.02	40.72	19.73	31.71	12.39	39.64
11	MED	HIGH	22.63	30.07	21.30	26.02	8.40	29.30
12	MED	HIGH	21.66	41.80	20.32	32.67	13.12	40.66
13	MED	MED	28.32	32.16	26.49	25.49	8.17	25.98
14	MED	MED	20.94	28.16	19.40	22.70	6.58	27.76
15	MED	MED	21.12	35.56	19.66	28.49	10.66	44.50
16	MED	LOW	33.18	17.06	30.44	13.51	3.80	14.08
17	MED	LOW	30.26	12.45	28.14	10.15	1.47	7.03
18	MED	LOW	32.25	17.78	29.43	13.11	3.83	15.38
19	LOW	HIGH	21.16	22.32	19.87	20.27	6.48	25.08
20	LOW	HIGH	22.65	25.45	21.04	21.69	10.74	35.11
21	LOW	HIGH	23.47	22.80	22.04	20.33	3.67	14.61
22	LOW	MED	30.59	18.52	28.61	16.87	1.49	5.52
23	LOW	MED	27.75	25.68	25.64	21.43	3.81	14.10
24	LOW	MED	33.81	20.01	31.64	17.73	3.92	12.13
25	LOW	LOW	40.16	7.97	37.44	7.13	5.78	17.80
26	LOW	LOW	40.56	11.78	37.10	9.36	4.33	13.89
27	LOW	LOW	42.87	8.76	39.71	7.63	2.10	6.64

Appendix A.3

Harvest 3 data for threshing of marigold flowers at three different moisture contents and three adjustments in plate gap height.

			After Drying and Threshing Period		After Oven Drying			
Test Number	Target Moisture Content	Plate Gap Height	Material Removed Weight(grams)	Receptacle Weight(grams)	Material Removed Weight(grams)	Receptacle Weight(grams)	Petals Not Removed(grams)	Percent Petals Not Removed(%)
1	HIGH	HIGH	12.93	27.15	12.08	20.92	7.56	58.11
2	HIGH	HIGH	10.61	23.21	9.78	18.05	6.98	42.11
3	HIGH	HIGH	11.03	22.73	10.39	17.94	5.61	36.72
4	HIGH	MED	15.38	19.89	14.18	15.29	4.91	28.25
5	HIGH	MED	12.37	18.98	11.47	14.48	4.08	28.26
6	HIGH	MED	13.33	22.34	12.48	16.28	4.35	27.88
7	HIGH	LOW	17.56	18.08	15.51	12.38	4.56	26.87
8	HIGH	LOW	18.13	20.63	16.35	14.01	4.11	23.87
9	HIGH	LOW	18.67	16.33	16.62	11.32	2.70	17.28
10	MED	HIGH	11.61	20.86	10.85	17.96	5.90	35.94
11	MED	HIGH	11.16	22.31	10.37	18.62	6.68	40.20
12	MED	HIGH	10.53	25.20	9.88	21.26	8.23	47.54
13	MED	MED	13.87	17.23	13.02	14.37	3.77	24.07
14	MED	MED	14.87	17.68	13.78	15.39	3.77	22.33
15	MED	MED	17.90	17.71	16.71	15.38	4.33	22.40
16	MED	LOW	30.79	3.87	28.37	3.32	0.40	2.05
17	MED	LOW	29.49	5.90	27.22	4.81	0.77	4.24
18	MED	LOW	26.97	7.03	24.83	5.69	1.06	5.85
19	LOW	HIGH	12.52	15.76	11.90	14.11	2.76	19.12
20	LOW	HIGH	11.44	16.64	15.03	10.80	3.98	26.91
21	LOW	HIGH	13.47	14.69	12.80	13.48	2.82	18.99
22	LOW	MED	17.06	12.35	16.32	11.85	1.48	10.22
23	LOW	MED	15.37	14.56	14.39	12.34	2.18	14.47
24	LOW	MED	15.11	13.55	14.36	12.00	1.50	10.43
25	LOW	LOW	23.61	5.14	22.31	4.15	0.24	1.51
26	LOW	LOW	23.17	6.79	21.72	5.81	0.40	2.56
27	LOW	LOW	23.43	5.86	21.68	5.10	0.64	4.01

Appendix A.4

Harvest 4 data for threshing of marigold flowers at three different moisture contents and three adjustments in plate gap height.

			After Drying and Threshing Period		After Oven Drying			
Test Number	Target Moisture Content	Plate Gap Height	Material Removed Weight(grams)	Receptacle Weight(grams)	Material Removed Weight(grams)	Receptacle Weight(grams)	Petals Not Removed(grams)	Percent Petals Not Removed(%)
1	HIGH	HIGH	4.76	39.99	4.44	23.21	12.05	-
2	HIGH	HIGH	4.00	37.10	3.73	21.97	11.37	-
3	HIGH	HIGH	4.85	29.00	4.53	18.85	8.78	45.68
4	HIGH	MED	6.62	31.62	6.15	19.59	9.31	61.33
5	HIGH	MED	5.36	33.57	5.02	19.54	9.21	43.48
6	HIGH	MED	6.58	27.21	6.14	17.14	7.55	57.11
7	HIGH	LOW	8.97	27.04	8.28	15.88	6.75	48.21
8	HIGH	LOW	9.35	33.40	8.65	19.11	7.91	50.53
9	HIGH	LOW	7.77	35.28	7.15	19.66	8.42	57.46
10	MED	HIGH	12.41	17.46	11.71	14.32	5.11	31.24
11	MED	HIGH	12.90	12.74	12.27	11.68	2.47	17.18
12	MED	HIGH	12.53	19.49	11.90	15.75	5.12	30.44
13	MED	MED	15.65	12.88	14.75	11.34	2.26	14.09
14	MED	MED	15.62	10.46	14.75	9.53	1.67	11.33
15	MED	MED	10.09	21.39	9.58	16.25	6.47	41.32
16	MED	LOW	14.54	21.82	13.24	17.18	3.80	26.64
17	MED	LOW	19.39	6.55	18.29	5.29	1.22	8.29
18	MED	LOW	20.03	8.58	18.54	6.78	1.71	10.89
19	LOW	HIGH	11.93	15.02	11.253	13.13	3.50	24.49
20	LOW	HIGH	14.28	13.03	13.511	11.965	1.95	8.86
21	LOW	HIGH	12.60	10.72	11.88	10.119	1.47	11.32
22	LOW	MED	15.62	10.22	14.708	9.57	1.10	7.53
23	LOW	MED	12.92	10.30	12.197	9.529	1.45	11.37
24	LOW	MED	13.17	10.11	12.448	9.463	1.23	9.83
25	LOW	LOW	20.68	3.51	19.53	3.288	0.19	1.38
26	LOW	LOW	20.08	5.50	18.916	5.148	0.29	1.92
27	LOW	LOW	21.46	4.38	20.27	4.032	0.28	1.90

Appendix B.1

% PNR values for a constant plate gap height of 6.5 mm.

Plate gap height	Conveyor speed(cm/s)	Top plate speed(cm/s)	%pnr
6.5 mm	27.94	27.94	12.18
6.5 mm	27.94	27.94	12.15
6.5 mm	27.94	27.94	5.14
6.5 mm	27.94	13.97	22.40
6.5 mm	27.94	13.97	2.78
6.5 mm	27.94	13.97	9.97
6.5 mm	55.88	55.88	13.73
6.5 mm	55.88	55.88	7.72
6.5 mm	55.88	55.88	16.90
6.5 mm	55.88	27.94	17.83
6.5 mm	55.88	27.94	9.52
6.5 mm	55.88	27.94	5.96
6.5 mm	83.82	83.82	8.39
6.5 mm	83.82	83.82	4.87
6.5 mm	83.82	83.82	8.11
6.5 mm	83.82	41.91	7.52
6.5 mm	83.82	41.91	9.74
6.5 mm	83.82	41.91	8.48
		Average=	10.19
		Standard deviation=	4.99

Appendix B.2

% PNR values for a constant plate gap height of 9.7 mm.

Plate gap height	Conveyor speed(cm/s)	Top plate speed(cm/s)	%pnr
9.7mm	27.94	27.94	27.94
9.7mm	27.94	27.94	29.40
9.7mm	27.94	27.94	24.39
9.7mm	27.94	13.97	27.67
9.7mm	27.94	13.97	28.30
9.7mm	27.94	13.97	20.97
9.7mm	55.88	55.88	24.01
9.7mm	55.88	55.88	31.01
9.7mm	55.88	55.88	27.97
9.7mm	55.88	27.94	33.17
9.7mm	55.88	27.94	35.50
9.7mm	55.88	27.94	16.63
9.7mm	83.82	83.82	19.24
9.7mm	83.82	83.82	28.25
9.7mm	83.82	83.82	28.37
9.7mm	83.82	41.91	32.27
9.7mm	83.82	41.91	35.09
9.7mm	83.82	41.91	19.68
		Average=	27.21
		Standard deviation=	5.45

Appendix B.3

% PNR values for a constant plate gap height of 12.9 mm.

Plate gap height	Conveyor speed(cm/s)	Top plate speed(cm/s)	%pnr
12.9 mm	27.94	27.94	26.16
12.9 mm	27.94	27.94	37.31
12.9 mm	27.94	27.94	38.45
12.9 mm	27.94	13.97	41.96
12.9 mm	27.94	13.97	40.44
12.9 mm	27.94	13.97	5.24
12.9 mm	55.88	55.88	19.17
12.9 mm	55.88	55.88	26.12
12.9 mm	55.88	55.88	24.63
12.9 mm	55.88	27.94	26.10
12.9 mm	55.88	27.94	36.44
12.9 mm	55.88	27.94	6.29
12.9 mm	83.82	83.82	23.35
12.9 mm	83.82	83.82	29.12
12.9 mm	83.82	83.82	24.36
12.9 mm	83.82	41.91	35.14
12.9 mm	83.82	41.91	27.97
12.9 mm	83.82	41.91	26.74
		Average=	27.50
		Standard deviation=	10.26

Appendix B.4

Anova table for the %pnr obtained due to varying belt and plate speeds.

Conveyor speed(cm/s)	Plate Speed(cm/s)	*Count*	*Sum*	*Average*	*Variance*
27.94	27.94	3	119.825	39.94166	6.276173
27.94	27.94	3	106.8257	35.60858	82.36689
27.94	27.94	3	99.20318	33.06773	59.35838
27.94	13.97	3	90.51985	30.17328	27.84131
27.94	13.97	3	106.3326	35.4442	21.85928
27.94	13.97	3	125.5509	41.85031	114.646
55.88	55.88	3	149.3528	49.78428	11.65239
55.88	55.88	3	144.549	48.18299	3.237622
55.88	55.88	3	145.2133	48.40444	3.412984
55.88	27.94	3	147.1168	49.03894	0.42079
55.88	27.94	3	133.2365	44.41215	8.101028
55.88	27.94	3	140.1417	46.71392	1.058209
83.82	83.82	3	114.0767	38.02556	98.76267
83.82	83.82	3	115.1394	38.3798	141.1557
83.82	83.82	3	119.1677	39.72258	1.367834
83.82	41.91	3	110.0447	36.68157	14.17577
83.82	41.91	3	98.9831	32.99437	12.1041
83.82	41.91	3	106.2455	35.41518	30.2101

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	1963.66161	17	115.5095	3.258852	0.00141
Within Groups	1276.014414	36	35.44484		
					F crit
Total	3239.676024	53			1.915321

Appendix C.1

Replication 1 data for fresh flowers collected during harvest 1 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	3.54	8.25	0.74	0.67	78.97	91.88
2	3.13	6.58	0.78	0.38	75.07	94.26
3	2.57	5.26	0.67	0.31	73.73	94.05
4	4.28	6.66	0.82	0.60	80.91	90.96
5	3.12	3.91	0.49	0.40	84.29	89.91
6	3.62	9.86	1.19	0.56	67.14	94.29
7	3.20	3.03	0.47	0.43	85.29	85.76
8	3.15	5.77	0.63	0.49	79.90	91.45
9	3.97	5.83	0.76	0.38	80.76	93.41
10	2.84	5.60	0.63	0.49	77.97	91.19
11	2.04	4.03	0.53	0.24	74.13	93.95
12	3.04	6.45	0.67	0.57	78.10	91.20
13	4.01	9.63	1.14	0.65	71.54	93.20
14	3.19	6.28	0.87	0.40	72.74	93.63
15	2.61	6.22	0.79	0.48	69.88	92.35
16	3.03	5.67	0.65	0.34	78.59	94.02
17	3.54	4.82	0.59	0.53	83.38	89.11
18	3.57	5.92	0.73	0.63	79.44	89.39
19	3.38	4.19	0.38	0.61	88.80	85.43
20	2.80	2.95	0.54	0.30	80.88	90.00
21	3.15	7.55	0.96	0.41	69.42	94.55
22	4.11	9.75	1.12	0.64	72.82	93.45
23	3.18	3.93	0.46	0.36	85.58	90.85
24	3.23	5.46	0.81	0.35	75.04	93.61
25	4.23	4.57	0.59	0.64	86.04	86.09
26	3.30	5.59	0.72	0.42	78.29	92.46
27	4.01	5.19	0.68	0.61	83.11	88.16
28	2.91	2.72	0.24	0.56	91.85	79.38
29	4.27	5.32	0.70	0.60	83.63	88.77
30	3.96	2.96	0.42	0.55	89.51	81.52
				Averages	79.23	90.61

Appendix C.2

Replication 2 data for fresh flowers collected during harvest 1 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	3.94	6.09	0.59	0.78	84.99	87.14
2	3.15	5.58	0.57	0.71	82.06	87.26
3	4.68	8.87	0.84	1.27	82.00	85.69
4	4.57	7.21	0.77	0.94	83.10	86.91
5	3.82	6.75	0.57	0.91	85.08	86.55
6	2.78	4.43	0.46	0.59	83.33	86.78
7	3.19	8.61	0.64	1.12	79.86	86.97
8	3.94	6.78	0.53	0.83	86.58	87.82
9	3.28	5.51	0.50	0.70	84.91	87.22
10	3.00	6.22	0.58	0.84	80.59	86.52
11	3.67	4.30	0.59	0.61	83.91	85.82
12	2.88	6.80	0.64	0.98	77.91	85.62
13	3.21	5.16	0.49	0.60	84.79	88.35
14	3.17	6.07	0.53	0.81	83.22	86.68
15	3.26	6.44	0.57	0.80	82.62	87.64
16	2.88	5.55	0.47	0.70	83.58	87.48
17	3.97	7.22	0.81	1.11	79.66	84.59
18	2.77	4.47	0.46	0.51	83.49	88.51
19	2.77	3.87	0.53	0.56	80.87	85.50
20	4.14	8.76	0.73	1.07	82.33	87.74
21	3.07	7.30	0.59	0.93	80.84	87.23
22	4.75	8.83	0.88	1.21	81.46	86.29
23	3.34	4.82	0.51	0.63	84.87	86.91
24	4.05	8.04	0.68	1.04	83.11	87.05
25	3.81	5.36	0.62	0.71	83.87	86.71
26	3.97	9.78	0.68	1.20	82.96	87.78
27	4.29	6.40	0.69	0.85	84.02	86.69
28	3.73	9.40	0.69	1.16	81.38	87.67
29	2.84	5.50	0.56	0.73	80.46	86.69
30	4.76	4.27	0.76	0.57	84.06	86.65
				Averages	82.73	86.88

Appendix C.3

Replication 3 data for fresh flowers collected during harvest 1 experiments.

specimen	before oven drying flower weights		after oven drying flower weights		moisture contents	
number	receptacle	petal	receptacle	petal	receptacle	petal
1	4.05	5.69	0.83	0.81	79.53	85.77
2	4.19	6.56	0.68	0.88	83.77	86.59
3	3.73	4.08	0.58	0.59	84.45	85.52
4	5.16	7.02	0.96	0.98	81.38	86.03
5	3.26	4.14	0.64	0.65	80.36	84.31
6	4.93	8.66	0.82	1.02	83.36	88.22
7	3.04	3.41	0.51	0.54	83.24	84.15
8	5.44	8.91	0.85	1.21	84.37	86.42
9	4.88	6.86	0.75	0.94	84.62	86.29
10	4.22	6.48	0.72	0.92	82.93	85.80
11	3.65	3.94	0.56	0.54	84.64	86.31
12	4.40	5.18	0.63	0.71	85.68	86.30
13	4.05	6.60	0.71	0.90	82.47	86.37
14	4.34	5.22	0.74	0.81	82.95	84.48
15	4.94	5.79	0.76	0.83	84.61	85.66
16	3.26	4.26	0.60	0.64	81.62	84.97
17	3.39	4.33	0.54	0.60	84.08	86.13
18	4.07	6.54	0.70	0.83	82.81	87.30
19	4.46	9.53	0.84	1.24	81.16	86.98
20	4.41	8.55	0.78	1.05	82.31	87.72
21	3.68	5.18	0.59	0.73	83.98	85.90
22	3.81	7.25	0.61	0.96	83.99	86.76
23	4.09	7.61	0.84	1.06	79.47	86.08
24	3.65	6.51	0.74	0.95	79.72	85.42
25	4.43	5.54	0.62	0.74	86.00	86.64
26	3.70	4.63	0.56	0.65	84.86	85.96
27	4.63	6.18	0.83	0.85	82.06	86.25
28	3.25	2.86	0.55	0.45	83.08	84.29
29	2.92	5.45	0.49	0.69	83.21	87.34
30	3.35	2.20	0.56	0.33	83.26	85.00
				Averages	83.00	86.03

Appendix C.4

Replication 1 data for fresh flowers collected during harvest 2 experiments.

specimen	before oven drying flower weights		after oven drying flower weights		moisture contents	
number	receptacle	petal	receptacle	petal	receptacle	petal
1	6.59	0.73	3.54	0.43	88.92	87.85
2	3.94	0.51	2.47	0.35	87.16	85.83
3	4.50	0.56	2.71	0.36	87.62	86.57
4	5.81	0.70	3.08	0.44	87.90	85.71
5	4.49	0.54	2.78	0.37	87.93	86.62
6	7.25	0.81	3.10	0.40	88.90	87.00
7	7.16	0.81	3.44	0.43	88.69	87.56
8	5.17	0.62	2.88	0.42	88.01	85.31
9	4.08	0.52	2.75	0.42	87.25	84.65
10	3.16	0.39	1.87	0.23	87.56	87.81
11	8.47	1.02	3.75	0.57	87.92	84.75
12	6.29	0.94	4.63	0.80	84.99	82.83
13	4.81	0.64	2.69	0.40	86.69	85.06
14	8.64	1.01	4.10	0.60	88.28	85.29
15	3.76	0.51	2.40	0.39	86.33	83.88
16	6.85	0.84	3.64	0.53	87.75	85.35
17	5.23	0.63	3.31	0.45	87.95	86.28
18	5.15	0.64	3.42	0.49	87.67	85.64
19	5.36	0.64	2.75	0.39	87.99	85.96
20	6.42	0.71	2.91	0.39	89.02	86.67
21	5.87	0.65	2.80	0.37	88.94	86.89
22	4.65	0.54	2.54	0.34	88.45	86.77
23	6.81	0.89	4.25	0.60	87.00	85.95
24	9.07	1.16	3.47	0.61	87.18	82.31
25	7.27	0.77	3.98	0.56	89.41	85.99
26	7.81	0.82	3.64	0.43	89.50	88.32
27	7.40	0.92	3.34	0.47	87.55	86.05
28	5.59	0.73	3.89	0.57	86.98	85.30
29	4.13	0.49	2.77	0.38	88.11	86.25
30	5.79	0.73	2.95	0.44	87.39	85.08
				Averages	87.84	85.85

Appendix C.5

Replication 2 data for fresh flowers collected during harvest 2 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	6.23	0.71	3.28	0.46	88.54	85.99
2	5.18	0.59	3.01	0.42	88.62	86.08
3	5.20	0.67	2.82	0.49	87.07	82.75
4	6.63	0.80	3.83	0.51	87.98	86.71
5	13.76	1.42	5.15	0.72	89.69	86.02
6	5.99	0.82	3.10	0.56	86.24	82.07
7	6.42	0.77	2.57	0.41	88.01	84.11
8	5.48	0.65	3.03	0.42	88.22	86.12
9	7.30	0.83	3.04	0.48	88.58	84.17
10	3.73	0.48	2.16	0.33	87.13	84.63
11	7.21	0.86	2.89	0.50	88.09	82.61
12	6.37	0.69	2.86	0.44	89.25	84.62
13	4.98	0.62	2.58	0.39	87.48	85.02
14	8.10	1.03	3.61	0.63	87.33	82.65
15	8.58	-	3.73	0.58	-	84.42
16	12.26	1.41	4.68	0.77	88.50	83.54
17	6.50	0.80	2.54	0.41	87.63	84.04
18	4.62	0.53	2.27	0.36	88.50	84.26
19	6.18	-	3.16	0.53	-	83.17
20	6.02	0.72	2.50	0.40	88.12	83.83
21	7.70	0.90	3.40	0.54	88.26	84.07
22	9.41	0.96	4.33	0.54	89.82	87.51
23	7.53	0.90	3.47	0.53	88.05	84.59
24	8.49	0.94	3.75	0.55	88.93	85.44
25	9.46	1.12	3.80	0.61	88.18	83.91
26	6.24	0.79	2.80	0.44	87.29	84.33
27	5.53	0.64	2.66	0.42	88.43	84.10
28	5.63	0.76	3.16	0.53	86.58	83.35
29	5.50	0.73	3.25	0.55	86.66	83.17
30	5.84	0.64	2.69	0.41	89.07	84.68
				Averages	88.08	84.40

Appendix C.6

Replication 3 data for fresh flowers collected during harvest 2 experiments.

specimen number	before oven drying flower weights receptacle	before oven drying flower weights petal	after oven drying flower weights receptacle	after oven drying flower weights petal	moisture contents receptacle	moisture contents petal
1	3.65	0.52	2.37	0.45	85.82	81.11
2	7.09	0.94	2.84	0.54	86.69	81.16
3	4.29	0.57	2.80	0.45	86.74	84.07
4	3.89	0.56	2.49	0.41	85.69	83.63
5	3.75	0.57	2.86	0.53	84.85	81.62
6	7.63	0.98	2.84	0.54	87.09	80.97
7	7.52	0.97	3.60	0.62	87.08	82.69
8	4.80	0.68	2.65	0.49	85.81	81.40
9	4.08	0.56	1.92	0.35	86.28	82.00
10	5.81	0.78	3.03	0.47	86.51	84.64
11	3.70	0.52	2.23	0.41	85.98	81.59
12	3.43	0.53	2.09	0.42	84.56	79.97
13	6.02	0.90	3.88	0.71	85.10	81.74
14	4.28	0.62	2.09	0.45	85.48	78.66
15	4.64	0.57	2.11	0.32	87.69	84.81
16	7.26	0.85	3.25	0.55	88.26	83.05
17	3.10	0.41	2.87	0.48	86.68	83.19
18	6.05	0.73	2.67	0.43	87.94	83.86
19	6.35	0.77	2.69	0.45	87.89	83.17
20	5.93	0.82	3.13	0.59	86.14	81.28
21	5.87	0.83	2.54	0.50	85.83	80.38
22	4.18	0.57	3.41	0.65	86.29	80.93
23	5.54	0.67	2.48	0.37	87.97	85.20
24	5.58	0.71	2.22	0.37	87.29	83.59
25	4.08	0.51	2.29	0.35	87.41	84.51
26	7.47	0.98	2.83	0.54	86.88	80.74
27	6.22	0.84	2.51	0.44	86.53	82.34
28	4.21	0.53	2.19	0.33	87.52	84.96
29	8.34	1.02	3.31	0.55	87.77	83.49
30	6.22	0.84	3.13	0.56	86.47	82.25
				Averages	86.61	82.43

Appendix C.7

Replication 1 data for fresh flowers collected during harvest 3 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	4.51	0.62	2.46	0.47	86.19	80.81
2	4.81	0.68	2.52	0.50	85.95	80.02
3	4.92	0.66	2.15	0.44	86.68	79.48
4	6.36	0.86	2.96	0.52	86.48	82.38
5	3.79	0.45	1.55	0.26	88.13	83.29
6	6.21	0.81	2.98	0.59	86.96	80.17
7	5.82	0.80	2.48	0.57	86.21	77.08
8	5.71	0.63	2.36	0.40	88.89	82.95
9	4.80	0.65	2.79	0.53	86.50	80.95
10	5.41	0.76	2.80	0.51	85.93	81.70
11	3.82	0.48	1.72	0.33	87.53	80.92
12	2.87	0.33	1.42	0.25	88.38	82.65
13	3.35	0.39	1.61	0.24	88.49	85.39
14	4.18	0.55	2.14	0.41	86.80	80.93
15	3.68	0.42	1.75	0.32	88.55	81.77
16	3.84	0.51	1.76	0.33	86.78	81.35
17	3.23	0.45	2.38	0.42	85.98	82.23
18	6.25	0.97	3.59	0.76	84.53	78.90
19	4.32	0.54	2.68	0.44	87.53	83.41
20	6.14	0.84	2.91	0.61	86.31	79.12
21	4.70	0.53	2.32	0.37	88.67	84.04
22	4.23	0.49	2.01	0.34	88.39	83.16
23	3.89	0.56	2.31	0.50	85.64	78.57
24	4.59	0.68	3.29	0.66	85.08	79.94
25	5.83	0.77	2.43	0.51	86.73	78.90
26	5.21	0.69	2.07	0.43	86.80	79.16
27	3.62	0.54	2.50	0.49	84.98	80.30
28	5.58	0.73	2.87	0.52	86.94	81.99
29	7.21	0.82	2.82	0.46	88.55	83.64
30	2.77	0.38	2.02	0.36	86.19	82.40
				Averages	86.89	81.25

Appendix C.8

Replication 2 data for fresh flowers collected during harvest 3 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	6.45	0.73	2.92	0.48	88.67	83.69
2	5.69	0.68	2.30	0.43	87.99	81.35
3	4.31	0.56	1.92	0.37	87.10	80.60
4	5.98	0.91	2.67	0.55	84.83	79.45
5	3.90	0.46	1.65	0.30	88.19	81.86
6	3.07	0.48	1.86	0.41	84.24	78.09
7	8.30	1.04	2.92	0.60	87.50	79.52
8	4.07	0.62	3.05	0.58	84.80	81.14
9	5.09	0.68	2.36	0.41	86.75	82.76
10	5.98	0.98	2.96	0.66	83.65	77.74
11	5.96	0.74	2.82	0.47	87.57	83.33
12	4.39	0.53	1.93	0.31	88.01	84.11
13	2.87	0.39	1.44	0.26	86.27	82.10
14	3.95	0.62	2.37	0.51	84.29	78.47
15	4.31	0.69	2.30	0.48	84.10	78.97
16	3.55	0.51	1.92	0.35	85.59	81.66
17	3.98	0.55	2.57	0.54	86.30	79.07
18	7.60	0.87	2.57	0.43	88.52	83.43
19	7.56	1.00	3.19	0.60	86.81	81.34
20	4.12	0.61	2.00	0.40	85.21	79.75
21	3.58	0.42	1.48	0.24	88.41	84.00
22	3.68	0.67	1.88	0.41	81.92	77.97
23	5.59	-0.09	2.27	0.43	101.52	81.27
24	5.62	0.81	2.45	0.39	85.54	84.28
25	3.79	0.52	1.52	0.32	86.21	78.87
26	2.66	0.40	1.36	0.29	84.97	78.80
27	4.45	0.53	2.14	0.32	88.08	84.84
28	4.74	0.59	2.09	0.33	87.46	84.10
29	1.96	0.30	1.45	0.28	84.66	80.42
30	5.07	0.73	2.47	0.48	85.64	80.54
				Averages	86.69	81.12

Appendix C.9

Replication 3 data for fresh flowers collected during harvest 3 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	3.51	0.54	1.95	0.40	84.49	79.54
2	5.17	0.68	2.27	0.41	86.92	82.03
3	3.01	0.49	2.40	0.46	83.85	80.98
4	4.10	0.56	2.26	0.36	86.29	83.86
5	4.08	0.57	2.11	0.41	85.94	80.74
6	2.74	0.38	1.67	0.33	86.01	80.27
7	3.58	0.50	1.83	0.36	86.11	80.46
8	3.67	0.52	1.92	0.31	85.70	83.73
9	4.04	0.51	2.00	0.35	87.49	82.48
10	3.02	0.44	2.17	0.34	85.54	84.41
11	2.49	0.38	1.76	0.31	84.83	82.31
12	3.99	0.52	2.47	0.38	86.96	84.55
13	3.08	0.46	3.04	0.53	85.16	82.57
14	3.17	0.46	1.98	0.36	85.46	81.60
15	4.30	0.64	2.35	0.38	85.07	83.65
16	4.79	0.56	2.55	0.39	88.28	84.63
17	4.79	0.70	2.51	0.54	85.44	78.72
18	3.03	0.42	2.39	0.37	86.09	84.57
19	3.04	0.45	2.15	0.40	85.22	81.66
20	3.53	0.45	1.82	0.34	87.28	81.32
21	2.98	0.39	1.58	0.27	87.06	83.11
22	3.00	0.44	1.99	0.39	85.35	80.54
23	3.50	0.50	2.27	0.44	85.75	80.72
24	2.92	0.44	2.49	0.44	84.89	82.17
25	4.48	0.67	1.95	0.40	85.14	79.29
26	6.13	0.68	2.22	0.33	88.92	85.28
27	5.52	0.58	2.32	0.33	89.42	85.97
28	4.02	0.51	1.71	0.29	87.22	83.24
29	3.68	0.51	2.12	0.41	86.10	80.63
30	4.82	0.65	2.42	0.46	86.57	81.08
				Averages	86.15	82.20

Appendix C.10

Replication 1 data for fresh flowers collected during harvest 4 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	3.36	0.41	1.79	0.27	87.76	84.84
2	4.88	0.54	1.59	0.31	89.01	80.73
3	6.00	0.70	2.26	0.44	88.40	80.64
4	6.75	0.81	2.83	0.46	87.96	83.86
5	8.22	1.22	3.08	0.52	85.18	83.18
6	6.09	0.70	2.61	0.39	88.51	85.12
7	5.64	0.72	2.07	0.39	87.19	81.01
8	4.08	0.51	1.88	0.35	87.53	81.45
9	7.07	0.82	2.31	0.42	88.34	81.66
10	4.16	0.58	1.78	0.32	86.19	82.06
11	5.47	0.75	3.12	0.55	86.22	82.40
12	6.86	0.82	2.28	0.45	88.03	80.18
13	4.51	0.54	2.27	0.45	88.14	80.13
14	2.77	0.33	1.18	0.20	88.25	83.09
15	5.53	0.64	2.81	0.41	88.42	85.28
16	3.78	0.48	1.74	0.32	87.26	81.58
17	2.41	0.27	1.11	0.21	88.98	81.26
18	5.20	0.62	2.37	0.36	88.18	85.02
19	3.95	0.52	1.68	0.39	86.91	77.08
20	4.80	0.54	1.91	0.33	88.67	82.85
21	3.24	0.39	1.89	0.28	87.95	85.10
22	2.58	0.30	1.58	0.23	88.53	85.17
23	3.63	0.50	2.37	0.39	86.24	83.38
24	4.33	0.68	2.21	0.34	84.36	84.86
25	3.39	0.45	1.59	0.32	86.73	79.63
26	5.03	0.66	2.31	0.33	86.83	85.78
27	2.98	0.40	2.20	0.38	86.56	82.56
28	6.50	0.79	2.73	0.52	87.88	80.95
29	4.52	0.52	2.05	0.32	88.38	84.47
30	3.85	0.48	2.44	0.35	87.47	85.57
				Averages	87.53	82.70

Appendix C.11

Replication 2 data for fresh flowers collected during harvest 4 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	4.72	0.60	1.98	0.24	87.20	88.16
2	5.70	0.80	1.87	0.30	85.94	84.09
3	5.15	0.63	2.04	0.34	87.74	83.42
4	6.73	0.83	2.38	0.39	87.62	83.53
5	6.07	0.81	2.58	0.37	86.60	85.83
6	3.70	0.45	1.77	0.21	87.94	88.10
7	4.15	0.52	1.84	0.32	87.45	82.67
8	3.88	0.50	2.00	0.32	87.04	84.16
9	4.76	0.56	2.05	0.24	88.26	88.51
10	4.82	0.60	1.75	0.27	87.55	84.72
11	5.57	0.74	2.63	0.32	86.66	87.66
12	2.91	0.37	1.21	0.15	87.47	87.58
13	4.70	0.58	1.92	0.36	87.77	81.04
14	8.43	1.12	3.08	0.63	86.72	79.47
15	4.28	0.48	1.53	0.24	88.90	84.54
16	5.76	0.70	2.60	0.48	87.78	81.41
17	3.20	0.36	1.87	0.22	88.78	88.49
18	5.53	0.59	2.12	0.33	89.34	84.44
19	5.67	0.80	2.55	0.42	85.84	83.44
20	8.59	1.00	2.79	0.34	88.33	87.75
21	3.30	0.39	1.39	0.25	88.30	82.41
22	3.91	0.49	1.71	0.28	87.38	83.76
23	2.69	0.36	1.11	0.16	86.71	86.00
24	3.94	0.49	2.07	0.33	87.45	84.11
25	2.74	0.34	1.49	0.27	87.66	81.77
26	5.19	0.58	1.98	0.35	88.79	82.44
27	4.13	0.51	2.25	0.36	87.74	84.17
28	2.44	0.31	1.21	0.21	87.26	82.51
29	2.89	0.37	1.22	0.16	87.29	86.77
30	4.08	0.50	1.56	0.31	87.82	80.04
				Averages	87.58	84.43

Appendix C.12

Replication 3 data for fresh flowers collected during harvest 4 experiments.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	5.52	0.57	2.21	0.36	89.77	83.77
2	5.05	0.63	1.88	0.32	87.51	83.01
3	5.27	0.66	2.64	0.31	87.56	88.12
4	5.39	0.64	2.28	0.34	88.13	85.25
5	4.77	0.60	2.22	0.40	87.41	81.92
6	3.55	0.46	1.67	0.37	87.14	78.01
7	2.58	0.34	1.56	0.21	86.90	86.56
8	3.84	0.45	1.86	0.34	88.38	81.62
9	3.92	0.44	1.30	0.24	88.66	81.20
10	4.36	0.49	1.53	0.19	88.70	87.68
11	3.46	0.47	1.97	0.32	86.56	83.64
12	5.06	0.61	2.09	0.34	87.92	83.78
13	3.17	0.36	1.49	0.25	88.55	83.30
14	2.64	0.30	1.50	0.20	88.56	86.66
15	3.80	0.43	1.71	0.26	88.70	85.00
16	5.39	0.64	2.22	0.38	88.13	82.73
17	2.67	0.32	3.39	0.29	87.84	91.60
18	2.99	0.42	3.00	0.25	86.10	91.70
19	4.18	0.52	1.90	0.37	87.54	80.69
20	5.00	0.65	2.18	0.40	87.09	81.63
21	4.81	0.69	2.52	0.37	85.73	85.45
22	10.18	0.24	2.75	0.47	97.62	82.96
23	3.44	0.44	1.89	0.24	87.11	87.30
24	8.42	0.99	3.10	0.47	88.26	84.98
25	3.65	0.43	1.75	0.24	88.12	86.26
26	5.13	0.64	1.85	0.33	87.46	82.24
27	4.14	0.52	2.40	0.33	87.57	86.11
28	5.36	0.61	2.38	0.34	88.64	85.83
29	4.63	0.56	2.08	0.32	87.90	84.49
30	3.12	0.44	1.81	0.29	85.90	84.23
				Averages	88.05	84.59

Appendix D.1

Dried flower data targeted for high moisture content for harvest 1.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.95	1.32	0.59	0.72	37.75	45.80
2	1.08	1.27	0.72	0.91	34.04	28.61
3	0.74	0.65	0.44	0.50	39.97	22.64
4	0.85	0.99	0.75	0.92	11.74	7.04
5	0.61	0.79	0.47	0.61	22.82	22.84
6	1.87	1.61	1.05	1.19	43.75	26.15
7	1.13	1.26	0.71	0.89	37.26	29.34
8	1.15	1.42	0.59	0.73	48.87	48.91
9	2.73	2.76	1.21	1.72	55.84	37.63
10	1.43	1.23	0.86	0.92	39.69	25.47
11	1.25	0.95	0.73	0.75	41.61	21.24
12	1.86	1.52	0.87	0.86	53.31	43.58
13	1.11	1.12	0.62	0.70	44.47	37.58
14	2.15	1.17	1.16	0.89	45.87	24.10
15	0.63	0.70	0.55	0.56	13.06	20.11
16	2.06	1.98	0.85	1.03	58.62	48.10
17	1.32	1.18	0.85	0.89	35.74	24.26
18	1.14	1.46	0.61	0.81	46.80	44.34
19	1.23	2.09	0.79	1.14	35.32	45.35
20	1.04	1.54	0.76	0.92	27.03	40.29
21	0.70	0.96	0.61	0.79	12.88	17.67
22	1.07	0.71	0.74	0.56	30.84	21.10
23	1.04	0.53	0.65	0.44	37.64	16.95
24	0.91	1.10	0.57	0.63	37.24	42.69
25	0.66	0.82	0.52	0.62	21.37	24.30
26	1.09	0.69	0.56	0.60	48.76	13.01
27	0.67	0.60	0.46	0.50	31.53	16.61
28	0.61	0.61	0.38	0.45	37.77	26.27
29	1.02	0.40	0.50	0.32	51.23	19.90
30	0.65	0.67	0.48	0.45	26.19	32.69
				Averages	36.97	29.15
			Standard	Deviations=	12.35	11.54
			Coefficients	of Variation=	0.33	0.40

Appendix D.2

Dried flower data targeted for medium moisture content for harvest 1.

specimen number	before oven drying flower weights receptacle	before oven drying flower weights petal	after oven drying flower weights receptacle	after oven drying flower weights petal	moisture contents receptacle	moisture contents petal
1	0.65	0.76	0.57	0.70	12.31	7.89
2	0.82	1.13	0.59	0.86	28.05	23.89
3	0.85	0.84	0.66	0.70	22.35	16.67
4	0.52	0.36	0.45	0.31	13.46	13.89
5	0.93	0.79	0.58	0.57	37.63	27.85
6	0.92	0.77	0.78	0.69	15.22	10.39
7	0.67	0.85	0.63	0.67	5.97	21.18
8	0.79	0.52	0.67	0.47	15.19	9.62
9	0.70	1.17	0.65	1.08	7.14	7.69
10	1.12	0.89	0.88	0.79	21.43	11.24
11	0.39	0.41	0.35	0.37	10.26	9.76
12	0.46	0.60	0.41	0.54	10.87	10.00
13	1.07	0.74	0.64	0.65	40.19	12.16
14	0.82	0.90	0.55	0.66	32.93	26.67
15	0.80	0.84	0.71	0.76	11.25	9.52
16	0.50	0.48	0.46	0.44	8.00	8.33
17	0.86	0.98	0.71	0.85	17.44	13.27
18	0.43	0.59	0.38	0.54	11.63	8.47
19	1.18	1.24	0.79	1.01	33.05	18.55
20	0.97	1.27	0.77	1.00	20.62	21.26
21	0.63	0.64	0.54	0.57	14.29	10.94
22	0.71	0.77	0.62	0.67	12.68	12.99
23	0.63	0.32	0.48	0.30	23.81	6.25
24	0.94	1.05	0.83	0.98	11.70	6.67
25	0.49	0.46	0.44	0.42	10.20	8.70
26	0.94	0.90	0.83	0.82	11.70	8.89
27	0.87	0.71	0.61	0.62	29.89	12.68
28	0.93	0.88	0.69	0.77	25.81	12.73
29	0.65	0.49	0.43	0.42	33.85	14.29
30	0.89	1.10	0.58	0.83	34.83	24.55
				Averages	19.46	13.57
			Standard	Deviations=	10.14	6.18
			Coefficients	of Variation=	0.52	0.46

Appendix D.3

Dried flower data targeted for low moisture content for harvest 1.

specimen	before oven drying flower weights		after oven drying flower weights		moisture contents	
number	receptacle	petal	receptacle	petal	receptacle	petal
1	0.61	0.82	0.57	0.73	6.54	11.02
2	0.83	1.06	0.68	0.82	18.18	22.73
3	0.81	0.73	0.66	0.67	18.45	8.23
4	0.99	1.10	0.76	0.88	23.19	19.93
5	0.88	0.86	0.77	0.72	12.50	16.32
6	0.73	1.14	0.66	1.05	9.55	7.92
7	0.87	0.54	0.70	0.48	19.56	11.09
8	0.55	0.88	0.52	0.83	5.46	5.71
9	1.00	0.67	0.66	0.56	34.17	16.32
10	0.65	0.72	0.53	0.65	18.38	9.74
11	1.21	0.88	0.84	0.70	30.55	20.48
12	0.72	0.73	0.59	0.68	18.13	6.88
13	0.55	0.67	0.50	0.61	9.12	8.94
14	0.65	0.78	0.60	0.71	7.68	9.03
15	0.66	0.85	0.55	0.69	16.77	18.91
16	0.70	0.75	0.52	0.58	25.64	22.82
17	0.96	0.59	0.80	0.52	16.72	11.80
18	1.20	0.95	0.70	0.83	41.92	12.62
19	0.34	0.31	0.30	0.28	11.80	9.65
20	0.61	0.75	0.49	0.62	19.80	17.36
21	0.58	0.70	0.54	0.64	6.91	8.55
22	0.69	1.05	0.62	0.82	10.14	21.88
23	0.57	0.57	0.53	0.53	7.07	7.01
24	0.91	1.35	0.81	1.11	10.95	17.76
25	0.75	0.81	0.67	0.64	10.74	20.91
26	0.64	0.57	0.57	0.45	10.99	20.98
27	0.83	0.91	0.64	0.72	23.00	20.83
28	0.66	0.47	0.52	0.43	21.24	8.53
29	0.71	0.78	0.64	0.68	9.93	12.79
30	0.62	0.49	0.53	0.41	14.54	16.23
				Averages	16.32	14.10
			Standard	Deviations=	8.68	5.61
			Coefficients	of Variation=	0.53	0.40

Appendix D.4

Dried flower data targeted for high moisture content for harvest 2.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.90	1.25	0.69	0.93	23.41	25.94
2	0.33	0.27	0.21	0.21	36.28	20.90
3	0.69	0.62	0.41	0.51	40.87	18.81
4	0.87	1.24	0.65	0.93	25.09	24.78
5	0.38	0.83	0.21	0.56	45.77	32.29
6	0.55	0.97	0.45	0.80	18.61	17.49
7	0.53	0.59	0.44	0.47	16.26	21.32
8	0.51	0.57	0.43	0.43	14.73	23.36
9	0.69	1.30	0.52	0.87	24.09	33.46
10	1.00	1.32	0.64	0.90	36.13	31.84
11	1.38	2.86	1.41	0.88	-2.54	69.22
12	1.01	1.29	0.56	0.70	44.94	46.29
13	0.47	0.62	0.39	0.48	17.45	22.33
14	0.56	1.08	0.30	0.51	46.95	52.68
15	0.78	1.37	0.47	0.77	39.95	43.90
16	0.40	0.41	0.23	0.29	41.41	28.64
17	1.00	0.86	0.80	0.74	20.26	14.47
18	0.50	0.90	0.34	0.75	31.94	16.81
19	0.93	1.47	0.61	1.06	34.37	28.13
20	0.44	0.70	0.39	0.63	11.44	10.41
21	0.74	1.29	0.63	-	15.20	-
22	0.57	0.49	0.49	0.42	13.49	15.59
23	0.60	0.82	0.49	-	17.45	-
24	0.88	1.12	0.59	0.75	33.26	33.45
25	0.63	1.06	0.51	0.92	18.31	12.59
26	0.64	1.02	0.49	0.77	23.05	24.80
27	0.19	0.46	0.16	0.41	16.40	9.85
28	0.86	1.27	0.59	0.73	31.66	42.45
29	0.46	0.65	0.33	0.38	28.57	41.36
30	0.98	0.77	0.51	0.49	48.37	36.93
				Averages	27.11	28.58
			Standard	Deviations=	12.65	13.82
			Coefficients	of Variation=	0.47	0.48

Appendix D.5

Dried flower data targeted for medium moisture content for harvest 2.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.89	0.66	0.80	0.60	9.46	9.85
2	0.63	0.66	0.54	0.59	14.22	10.23
3	0.48	0.84	0.41	0.70	14.70	16.29
4	0.77	0.85	0.70	0.78	9.30	8.11
5	0.41	0.88	0.36	0.81	11.00	8.50
6	1.03	1.59	0.71	1.26	30.70	20.63
7	0.82	0.99	0.64	0.74	22.47	24.47
8	0.96	1.61	0.74	1.14	22.42	29.40
9	0.78	1.44	0.61	1.04	21.94	27.39
10	0.39	0.79	0.34	0.70	12.79	11.46
11	0.69	1.45	0.52	1.15	24.82	20.46
12	0.49	0.71	0.42	0.52	13.47	26.52
13	0.50	0.88	0.44	0.75	10.87	14.32
14	0.80	1.55	0.51	0.98	36.26	36.52
15	0.39	0.65	0.33	0.57	14.21	11.42
16	0.50	0.51	0.38	0.42	24.80	19.26
17	0.83	0.61	0.73	0.54	11.38	12.87
18	0.79	1.84	0.68	1.61	14.56	12.61
19	0.87	1.00	0.58	0.79	33.03	21.30
20	1.00	2.04	0.67	1.36	32.96	32.97
21	0.68	1.00	0.66	0.92	3.37	7.89
22	0.80	0.73	0.67	0.65	15.83	10.66
23	0.70	0.71	0.65	0.61	7.43	14.02
24	0.77	1.06	0.69	0.95	10.85	10.12
25	0.55	0.89	0.49	0.81	9.34	8.58
26	0.69	0.92	0.64	0.83	7.49	9.05
27	0.58	1.20	0.43	0.89	25.65	25.63
28	0.37	0.60	0.32	0.47	12.57	21.46
29	1.13	1.86	0.87	1.39	22.76	25.17
30	0.33	0.85	0.27	0.77	17.96	8.94
				Averages	17.29	17.20
			Standard	Deviations=	8.60	8.27
			Coefficients	of Variation=	0.50	0.48

Appendix D.6

Dried flower data targeted for low moisture content for harvest 2.

specimen	before oven drying flower weights		after oven drying flower weights		moisture contents	
number	receptacle	petal	receptacle	petal	receptacle	petal
1	0.61	0.82	0.75	0.56	8.69	9.10
2	0.84	1.17	0.92	0.67	19.86	21.25
3	0.62	0.93	0.84	0.54	12.82	9.74
4	0.61	0.96	0.85	0.55	9.26	11.46
5	0.48	1.10	0.92	0.41	13.84	16.59
6	0.55	0.87	0.79	0.48	11.19	9.61
7	0.63	1.01	0.91	0.56	10.35	9.91
8	0.76	1.33	1.23	0.69	9.20	7.16
9	0.58	0.83	0.75	0.52	11.82	9.21
10	0.73	1.21	0.91	0.62	14.64	24.73
11	0.59	1.18	1.09	0.52	12.52	8.20
12	0.52	0.75	0.66	0.46	11.80	12.05
13	0.59	1.01	0.92	0.53	10.49	8.88
14	0.54	1.02	0.92	0.46	13.27	9.62
15	0.39	0.67	0.61	0.34	12.63	8.85
16	0.53	0.88	0.70	0.44	16.07	20.46
17	0.57	0.75	0.67	0.51	10.18	10.40
18	0.45	0.78	0.70	0.38	15.56	10.28
19	0.44	0.63	0.56	0.39	12.84	11.08
20	0.86	1.34	1.23	0.77	10.48	8.35
21	0.42	0.84	0.77	0.37	12.62	8.58
22	0.49	0.70	0.63	0.44	11.94	10.13
23	0.91	1.69	1.39	0.75	17.22	17.83
24	0.67	1.23	1.08	0.59	11.49	12.74
25	0.53	0.98	0.90	0.47	10.92	7.94
26	0.61	1.18	1.02	0.52	14.19	14.27
27	0.44	0.70	0.63	0.38	13.74	10.54
28	0.45	0.72	0.64	0.39	12.28	10.74
29	0.63	0.86	0.76	0.56	11.45	10.96
30	0.48	0.93	0.85	0.41	13.99	8.93
				Averages	12.58	11.65
			Standard	Deviations=	2.45	4.30
			Coefficients	of Variation=	0.19	0.37

Appendix D.7

Dried flower data targeted for high moisture content for harvest 3.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.42	0.37	0.37	0.33	12.26	11.29
2	0.43	0.61	0.35	0.48	18.71	21.15
3	0.70	0.88	0.52	0.67	25.75	23.43
4	0.60	0.58	0.50	0.51	16.58	11.09
5	0.43	0.75	0.28	0.66	33.18	11.66
6	0.23	0.51	0.20	0.46	11.74	8.68
7	0.59	0.80	0.55	0.73	6.30	8.54
8	0.90	1.09	0.74	0.94	18.00	13.58
9	0.54	0.70	0.45	0.54	16.91	22.01
10	0.47	0.47	0.39	0.36	17.20	23.82
11	0.42	0.65	0.31	0.57	24.52	12.50
12	0.84	0.52	0.52	0.36	38.20	30.53
13	0.55	0.65	0.40	0.52	27.47	19.38
14	0.46	0.57	0.32	0.44	29.87	22.67
15	0.56	0.60	0.39	0.45	29.64	24.75
16	0.42	0.62	0.35	0.51	15.55	17.48
17	1.12	0.55	0.67	0.47	40.34	13.92
18	0.12	0.53	0.09	0.42	30.33	19.77
19	0.40	0.56	0.33	0.47	16.54	15.92
20	0.38	0.60	0.36	0.55	7.29	8.79
21	0.67	-	-	-	-	-
22	0.75	1.04	0.49	0.66	34.09	36.07
23	0.97	1.15	0.73	0.83	25.13	27.76
24	0.21	0.27	0.18	0.22	17.06	18.01
25	0.37	0.71	0.33	0.64	10.75	9.76
26	0.35	0.58	0.28	0.44	19.14	24.66
27	0.65	0.75	0.42	0.56	35.90	25.13
28	0.50	0.37	0.42	0.33	16.77	12.40
29	0.71	0.60	0.52	0.50	26.91	16.69
30	0.27	0.52	0.24	0.46	11.90	11.66
				Averages	21.86	18.04
			Standard	Deviations=	9.38	7.18
			Coefficients	of Variation=	0.43	0.40

Appendix D.8

Dried flower data targeted for medium moisture content for harvest 3.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.43	0.51	0.41	0.45	6.24	11.57
2	0.73	1.23	0.67	0.91	8.34	26.14
3	0.32	0.57	0.29	0.53	8.72	7.33
4	0.36	0.50	0.34	0.47	7.44	6.22
5	0.45	0.59	0.38	0.55	15.81	6.32
6	0.30	0.53	0.28	0.50	7.89	5.83
7	0.47	0.81	0.43	0.61	7.49	24.88
8	0.65	1.09	0.51	0.83	20.90	23.57
9	0.42	0.60	0.38	0.51	10.29	14.36
10	0.46	0.79	0.43	0.74	6.97	6.70
11	0.54	1.06	0.49	1.00	8.72	5.95
12	0.46	0.41	0.43	0.37	6.71	9.38
13	0.52	0.73	0.47	0.65	9.44	10.34
14	0.41	0.64	0.37	0.55	9.54	14.64
15	0.58	0.71	0.54	0.65	7.28	8.04
16	0.52	0.77	0.47	0.69	9.39	10.62
17	0.48	0.74	0.45	0.68	6.49	9.03
18	0.31	0.53	0.28	0.50	9.94	7.12
19	0.39	0.40	0.35	0.36	8.57	10.92
20	0.57	0.82	0.52	0.72	7.58	12.90
21	0.72	0.80	0.62	0.74	13.97	6.53
22	0.49	0.85	0.44	0.69	11.31	19.11
23	0.80	0.73	0.73	0.66	9.01	9.05
24	0.37	0.42	0.34	0.39	8.36	7.82
25	0.78	1.05	0.64	0.83	18.60	21.08
26	0.38	0.54	0.35	0.50	9.37	8.66
27	0.46	0.67	0.40	0.61	13.15	9.57
28	0.35	0.32	0.32	0.27	8.52	14.38
29	0.62	1.06	0.53	0.33	15.09	8.86
30	0.31	0.85	0.64	0.68		19.62
				Averages	10.04	13.88
			Standard	Deviations=	3.65	6.00
			Coefficients	of Variation=	0.36	0.43

Appendix D.9

Dried flower data targeted for low moisture content for harvest 3.

specimen	before oven drying flower weights		after oven drying flower weights		moisture contents	
number	receptacle	petal	receptacle	petal	receptacle	petal
1	0.54	0.81	0.50	0.79	6.51	2.48
2	0.88	0.82	0.79	0.86	10.44	-4.40
3	0.47	0.84	0.43	0.77	7.28	8.01
4	0.57	0.85	0.53	0.81	6.90	4.48
5	0.71	1.08	0.60	0.90	16.27	16.53
6	0.44	0.61	0.41	0.59	6.83	4.23
7	0.47	0.63	0.44	0.59	5.32	6.40
8	0.58	0.82	0.55	0.78	5.37	4.88
9	0.49	0.86	0.46	0.82	6.33	4.90
10	0.46	0.43	0.42	0.39	9.17	7.94
11	0.34	0.68	0.32	0.64	6.45	5.19
12	0.31	0.27	0.29	0.24	6.21	11.94
13	0.41	0.82	0.39	0.74	5.17	9.30
14	0.09	0.19	0.09	0.17	8.51	10.58
15	0.38	0.43	0.36	0.40	5.53	6.70
16	0.53	0.45	0.47	0.42	12.10	7.56
17	0.43	0.55	0.41	0.52	4.19	6.86
18	0.15	0.49	0.13	0.45	9.66	6.78
19	0.35	0.55	0.32	0.50	8.02	9.29
20	0.40	0.53	0.38	0.50	4.29	6.24
21	0.26	0.46	0.24	0.43	5.08	6.15
22	0.33	0.37	0.31	0.33	4.27	8.74
23	0.62	0.59	0.59	0.54	3.89	7.50
24	0.42	0.44	0.39	0.41	6.68	7.69
25	0.64	0.63	0.60	0.66	6.53	-3.79
26	0.45	0.43	0.40	0.39	9.89	8.82
27	0.26	0.47	0.22	0.42	14.56	9.66
28	0.48	0.41	0.46	0.37	3.99	9.22
29	0.22	0.37	0.20	0.33	10.09	11.17
30	0.22	0.39	0.18	0.36	16.89	7.69
				Averages	7.75	6.96
			Standard	Deviations=	3.49	4.04
			Coefficients	of Variation=	0.45	0.58

Appendix D.10

Dried flower data targeted for high moisture content for harvest 4.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.95	1.79	0.53	1.13	44.46	37.22
2	0.65	0.57	0.33	0.46	49.23	19.86
3	0.65	0.97	0.48	0.74	26.70	23.32
4	0.37	0.48	0.23	0.35	38.32	27.62
5	0.70	1.16	0.44	0.72	36.98	37.62
6	0.74	1.34	0.53	0.96	29.17	28.84
7	0.76	1.52	0.51	1.03	32.80	32.39
8	0.55	0.88	0.41	0.66	25.68	24.37
9	0.35	0.71	0.27	0.51	22.88	28.33
10	0.74	0.85	0.39	0.69	46.76	19.60
11	0.42	0.63	0.25	0.39	41.84	37.90
12	0.77	1.19	0.50	0.75	34.93	37.03
13	1.02	1.60	0.52	1.02	48.97	36.29
14	0.51	0.68	0.37	0.49	28.38	27.25
15	0.42	0.81	0.31	0.59	25.71	27.34
16	0.39	0.38	0.23	0.28	41.03	25.46
17	0.89	1.04	0.49	0.66	45.19	36.69
18	0.52	0.98	0.30	0.56	42.14	42.87
19	0.41	0.43	0.22	0.33	47.30	22.30
20	0.49	0.80	0.40	0.57	18.72	27.80
21	0.91	1.65	0.58	1.01	36.98	38.78
22	0.42	0.62	0.30	0.44	27.64	29.35
23	0.56	0.83	0.35	0.49	37.59	40.27
24	0.93	1.34	0.59	0.82	36.49	39.22
25	0.48	1.13	0.33	0.67	32.02	40.85
26	0.25	0.47	0.19	0.34	21.54	26.96
27	0.30	0.34	0.23	0.29	22.37	13.65
28	0.45	0.46	0.26	0.31	42.83	31.59
29	0.40	0.41	0.25	0.29	38.31	29.95
30	0.61	0.96	0.39	0.60	37.19	36.75
				Averages=	35.34	30.92
			Standard	Deviations=	8.82	7.33
			Coefficients	of Variation=	0.25	0.24

Appendix D.11

Dried flower data targeted for medium moisture content for harvest 4.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.49	0.67	0.39	0.57	20.78	14.48
2	0.38	0.60	0.33	0.54	12.34	10.02
3	0.32	0.68	0.28	0.62	14.06	7.56
4	0.59	0.77	0.47	0.64	20.17	17.21
5	0.34	0.52	0.31	0.50	9.73	4.96
6	0.55	0.59	0.41	0.52	24.40	11.11
7	0.41	0.61	0.38	0.50	8.09	18.29
8	0.35	0.38	0.32	0.35	9.66	5.60
9	0.73	0.94	0.55	0.81	25.10	14.72
10	0.50	0.57	0.46	0.54	7.39	4.94
11	0.21	0.25	0.19	0.24	10.43	3.94
12	0.46	0.76	0.36	0.57	20.83	24.77
13	0.45	0.90	0.39	0.72	13.48	20.02
14	0.39	0.65	0.36	0.62	9.44	4.45
15	0.25	0.58	0.23	0.28	8.27	51.72
16	0.44	0.57	0.41	0.54	5.95	5.61
17	0.41	0.40	0.38	0.37	8.54	6.57
18	0.34	0.41	0.28	0.37	19.48	10.41
19	0.30	0.38	0.27	0.36	8.33	7.07
20	0.24	0.30	0.22	0.29	6.69	4.30
21	0.28	0.35	0.27	0.33	5.69	4.57
22	0.37	0.63	0.35	0.60	4.92	4.30
23	0.53	0.57	0.49	0.55	6.79	4.38
24	0.35	0.48	0.29	0.44	16.91	9.32
25	0.29	0.48	0.26	0.46	10.76	4.58
26	0.37	0.45	0.33	0.43	9.84	5.08
27	0.33	0.57	0.30	0.55	8.00	3.71
28	0.37	0.50	0.34	0.47	8.02	4.65
29	0.48	0.75	0.32	0.64	32.57	14.40
30	0.25	0.25	0.23	0.24	6.12	3.63
				Averages	12.43	10.21
			Standard	Deviations=	6.95	9.67
			Coefficients	of Variation=	0.56	0.95

Appendix D.12

Dried flower data targeted for low moisture content for harvest 4.

specimen number	before oven drying flower weights receptacle	petal	after oven drying flower weights receptacle	petal	moisture contents receptacle	petal
1	0.38	0.53	0.34	0.48	10.61	9.57
2	0.58	0.80	0.53	0.74	8.13	7.39
3	0.40	0.64	0.36	0.59	9.77	7.20
4	0.50	0.74	0.43	0.69	15.31	7.31
5	0.60	0.79	0.49	0.61	18.15	23.08
6	0.67	1.34	0.60	1.16	10.04	13.63
7	0.40	0.61	0.37	0.57	6.97	6.74
8	0.50	0.46	0.44	0.43	12.35	6.97
9	0.61	0.93	0.55	0.86	9.20	7.75
10	0.70	1.23	0.57	1.07	18.45	13.45
11	0.26	0.27	0.24	0.25	8.49	8.92
12	0.32	0.36	0.30	0.33	7.10	8.10
13	0.56	0.84	0.52	0.79	6.47	6.05
14	0.33	0.42	0.31	0.40	5.78	5.91
15	0.27	0.40	0.25	0.37	7.14	6.73
16	0.50	0.72	0.47	0.68	6.21	5.97
17	0.25	0.31	0.23	0.28	7.35	8.20
18	0.60	0.80	0.56	0.74	6.82	7.37
19	0.33	0.38	0.30	0.35	8.73	7.43
20	0.52	0.84	0.42	0.72	19.57	14.68
21	0.44	0.55	0.42	0.51	6.32	6.22
22	0.29	0.44	0.27	0.42	5.19	5.22
23	0.23	0.24	0.22	0.23	3.48	5.44
24	0.32	0.51	0.29	0.49	7.28	5.27
25	0.42	0.58	0.40	0.54	5.50	5.72
26	0.51	0.98	0.47	0.93	6.71	5.40
27	0.45	0.77	0.43	0.73	4.70	5.22
28	0.37	0.65	0.36	0.61	3.78	4.81
29	0.33	0.50	0.31	0.46	6.73	7.21
30	0.29	0.36	0.27	0.32	6.29	10.34
				Averages	8.62	8.11
			Standard	Deviations=	4.20	3.79
			Coefficients	of Variation=	0.49	0.47

Appendix E.1

Multiple Regression statistics for Harvest 1.

Regression Statistics	
Multiple R	0.94578945
R Square	0.89451769
Adjusted R Square	0.85935692
Standard Error	6.50465217
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2152.824928	1076.412	25.44079	0.001173651
Residual	6	253.8629994	42.3105		
Total	8	2406.687927			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	235.021522	33.76438439	6.960634	0.000437	152.4029897	317.640055	152.4029897	317.640055
X Variable 1(M.C.)	-1.4144134	0.238676529	-5.92607	0.001029	-1.998434241	-0.8303925	-1.99843424	-0.83039253
X Variable 2(Plate Gap)	-84.345497	21.24410504	-3.9703	0.007364	-136.3279871	-32.363006	-136.327987	-32.3630063

Appendix E.2

Multiple Regression Statistics for Harvest 2.

Regression Statistics	
Multiple R	0.9755066
R Square	0.9516132
Adjusted R Square	0.9354843
Standard Error	5.6280024
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	3737.605312	1868.803	59.00039	0.000113287
Residual	6	190.0464653	31.67441		
Total	8	3927.651777			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	217.23161	29.22960021	7.431905	0.000305	145.7092978	288.75391	145.7092978	288.7539127
X Variable 1(M.C.)	-2.7419141	0.266384418	-10.2931	4.91E-05	-3.393733738	-2.090094	-3.393733738	-2.09009441
X Variable 2(P.G.)	-63.815218	18.38097883	-3.47181	0.013274	-108.7918854	-18.83855	-108.7918854	-18.8385498

Appendix E.3

Multiple Regression Statistics for Harvest 3.

Regression Statistics	
Multiple R	0.936467758
R Square	0.876971863
Adjusted R Square	0.835962483
Standard Error	5.894453058
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1486.00232	743.0012	21.38467	0.001862144
Residual	6	208.4674611	34.74458		
Total	8	1694.469781			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	253.7415901	30.65464474	8.277427	0.000168	178.7323217	328.75086	178.7323217	328.750858
X Variable 1(M.C.)	-1.764541309	0.429878956	-4.10474	0.006324	-2.81641799	-0.712665	-2.81641799	-0.71266463
X Variable 2(P.G.)	-98.01195974	19.25120307	-5.09121	0.002241	-145.1179911	-50.90593	-145.117991	-50.9059283

Appendix E.4

Multiple Regression Statistics for Harvest 4.

Regression Statistics	
Multiple R	0.9553482
R Square	0.9126901
Adjusted R Square	0.8835868
Standard Error	6.5565341
Observations	9

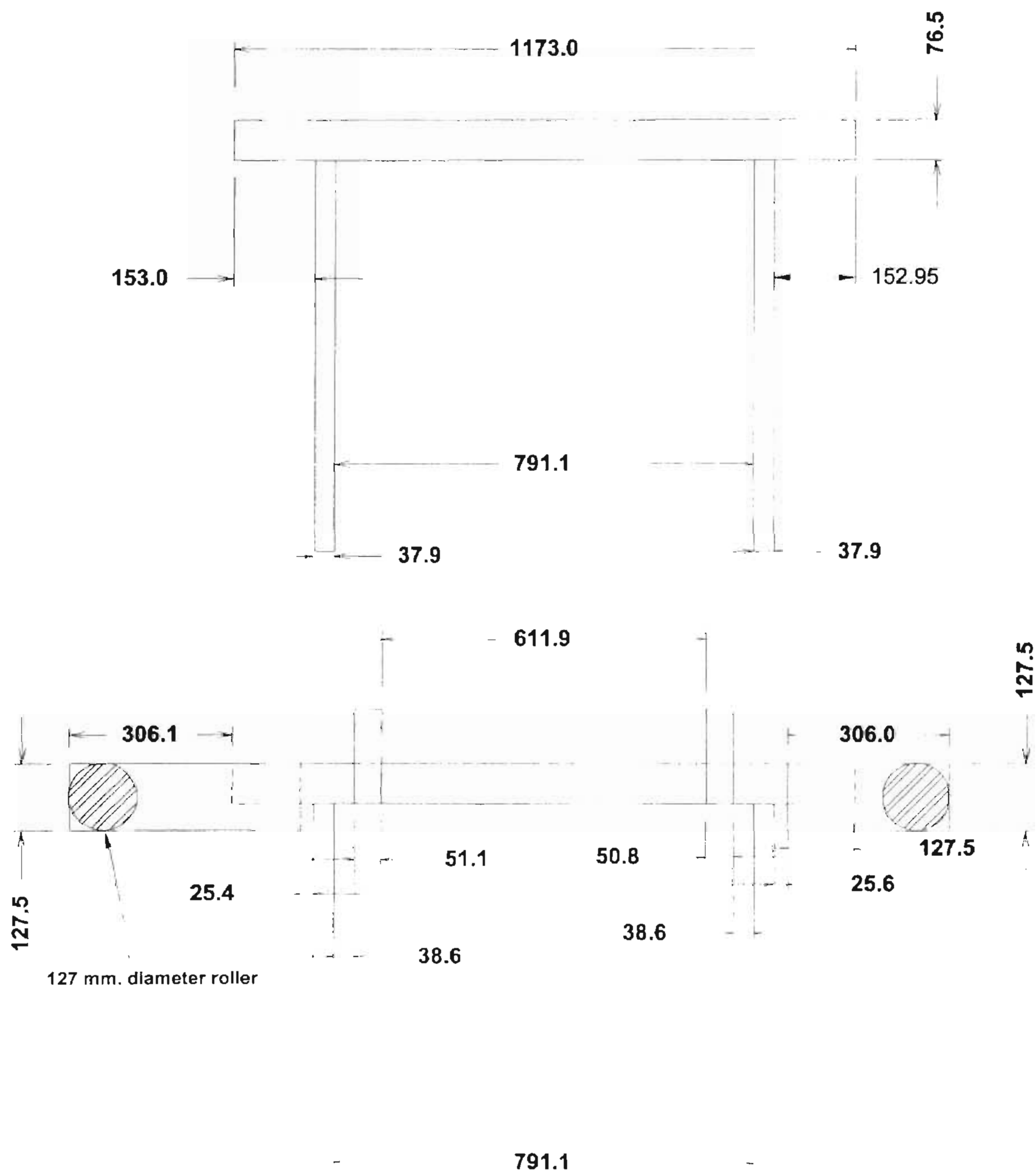
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2696.247988	1348.124	31.36037	0.000665565
Residual	6	257.9288341	42.98814		
Total	8	2954.176822			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	137.5199	33.71063923	4.079421	0.006506	55.0328757	220.00692	55.0328757	220.0069217
X Variable 1(M.C.)	-1.6653279	0.212363906	-7.84186	0.000227	-2.184963991	-1.1456917	-2.18496399	-1.145691716
X Variable 2(P.G.)	-23.709995	21.41355061	-1.10724	0.310593	-76.10710365	28.687114	-76.1071036	28.68711449

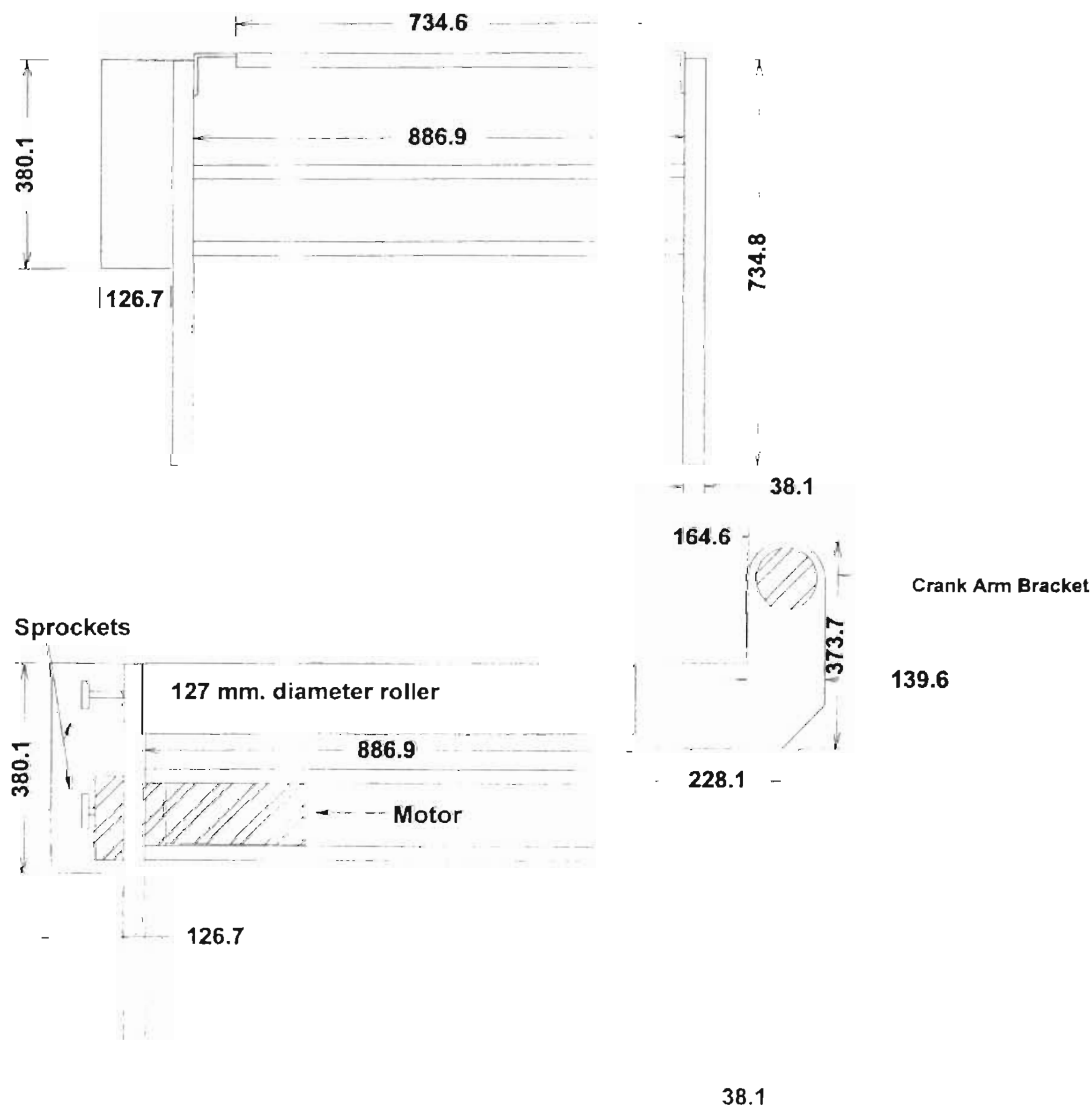
Appendix F.1

Side view of thresher table and attachments(measurements in mm.)



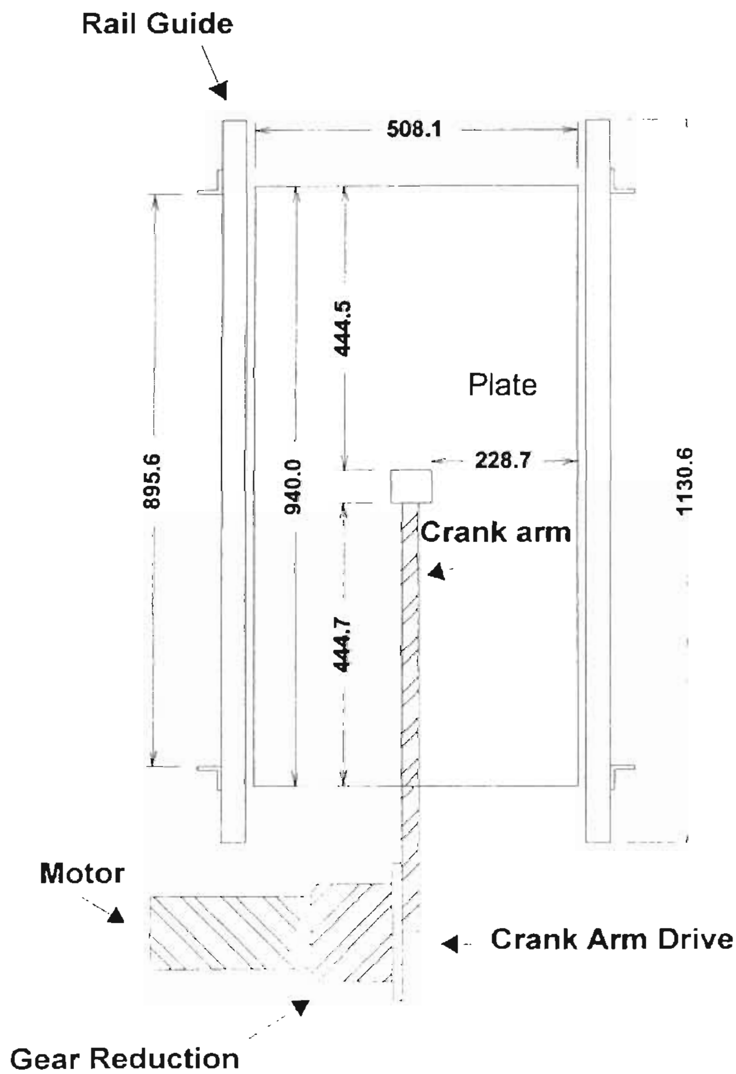
Appendix F.2

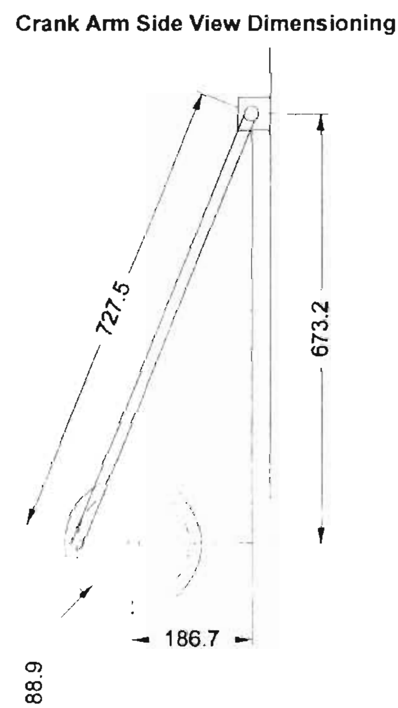
Front view of thresher table.



Appendix F.3

Top view of guide mechanism(side view of crank mechanism.)





VITA

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