Jojoba Harvesting Equipment

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Introduction

Prior to 1986, jojoba growers and researchers concentrated their development efforts on harvesters which collected seed directly from the plants. These machines straddled the row and used mechanical agitation to dislodge the seeds, which then fell onto a collection surface that passed under the lower plant branches.

Several factors indicated a need for alternative harvesting strategies. Average plant size was increasing as plantations matured, and large plants were sustaining considerable damage from the passage of the harvesters. As the harvestable acreage increased, many growers found that they could not harvest their fields often enough to minimize shattering losses. This meant that a considerable portion of the crop was being lost, and yields were decreased. To solve the problem, harvesters were provided with a more aggressive shaking action, which removed greener seeds and increased the time interval required between subsequent harvests. Unfortunately, this created another problem as the greener seeds required drying to prevent spoilage, significantly increasing harvesting costs. Additional problems were increasing maintenance costs, and the extensive repair times required by the aging and relatively complex over-the-row harvesters.

During the 1987 season ground harvesting systems began to receive considerable attention. The two types considered the most promising were sweeping and vacuuming. Both of these systems allow the seeds to mature on the plants and then fall naturally to the soil surface. In sweeping systems, the seeds are swept from under the plants and placed in a windrow. A second implement is then used to collect and clean the seed. Vacuuming systems lift the seeds directly from the soil surface under the plants, while a cleaner on the harvester removes some of the trash, soil and stones collected with the seed.

Although sweeping would appear to be a suitable approach, limited success has been realized. The main reason is that sweeping works well only on grass or on very firm soil surfaces where the amount of soil swept into the windrow is minimal. Jojoba fields are normally tilled once or more annually, and consequently the soil is barren and in a relatively loose condition. Unless jojoba fields are planted to some type of ground cover, it is doubtful that sweeping will become a generally accepted form of harvesting.

The more direct approach to jojoba harvesting is vacuuming the seeds directly from under the plants. This eliminates one operation, compared to a sweeping system, and consequently decreases costs by reducing both the number of operations and the cost of capital equipment. Because of these inherent advantages, development efforts in the Agricultural and Biosystems Engineering Department has concentrated on vacuuming systems.

Harvester Development

Research related to vacuum harvesting of jojoba seed has been ongoing at the University of Arizona since 1987. During the first year's studies, a guayule seed harvester was modified to allow gathering of basic data relating to harvesting requirements. Subsequently, three mechanized harvesters were designed, fabricated and field tested. The first of these was considered to be a pre-prototype and was used to gather basic information on equipment requirements, on which to base the design of the other two harvesters.

Basic Harvester Layout. The two harvesters were developed to meet varying field conditions. When jojoba is planted in rows eight feet apart there is insufficient distance between the rows to permit passage by a harvester. Trimming of the plants would permit harvester access, but would severely reduce yields obtained in subsequent years. To harvest in these fields, a straddle harvester was developed. The engine, cleaning components and operator's platform were positioned to pass over one row of plants, while the harvesting heads, conveying system and locomotion means passed between the straddled row and the adjacent rows. This harvester collected seed from the straddled row plus the insides of each adjacent row for a total of two rows at a time. Power for the harvester was provided by a 130 hp diesel engine, with a hydrostatic transmission used to provide infinitely variable ground speeds.
Although this harvester could also be used in fields having the more common 12 foot row spacing, its size prevented simple transport on roadways. A second harvester, designated as a between-the-row harvester, was developed to circumvent this limitation. The power unit and all of the associated harvesting components on this machine passed between two rows and collected seed from the inside half of each row for a total of one row at a time. This harvester was powered by a 100 hp air cooled diesel engine and was also equipped with a hydrostatic transmission. The all wheel powered, tricycle design used for this harvester provided low ground clearance and maximum maneuverability.

Functional Components. These were similar on both harvesters, with differences due primarily to machine size. Both harvesters utilized heads which passed along the ground and vacuumed seeds into the machine. Collected material was transported in a high velocity airstream into a separation chamber where the seed and other dense material fell from the airstream. The air was then exhausted through the fan to the atmosphere. The seed and other material passed from the separation chamber through a rotary valve type of airlock. The seed was then cleaned using drum type cleaners, combined with an airblast, before being conveyed into the seed hopper.

1. Fans. Both harvesters used two fans, with the larger unit's blades boride coated to reduce wear from material passing through them. At 2000 rpm each of these fans provided an airflow of 17630 cfm, with the total power requirement being 94 hp. The second harvester's fans provided a total airflow of 6980 cfm, when driven at 1600 rpm, and required only 40 hp to operate them.

2. Harvesting Heads. There were four pairs of heads on the straddle harvester, with each pair harvesting a width of 30 inches. The height of the opening at the head face was 2.75 inches, yielding an air velocity at the face of 256 ft/s. The heads were oriented vertically, with the face being held approximately 1.5 inches above the soil surface. Height was maintained by gauge wheels ahead, and behind each pair of heads. To accommodate variability in row spacing the lateral position of each pair of heads could be adjusted hydraulically from the operator's platform. There were two pairs of heads on the between-the-row harvester, with each pair measuring 36 inches in width. These heads were inclined at an angle 20 degrees above the horizontal. Air velocity at the 2.5 inch high face opening was 186 ft/s. These heads were pulled along the ground surface by two drag links attached to the front lip of each head, while a roller mounted at the rear of each head supported the majority of the weight, allowing the front edge to glide over the soil surface.

3. Separation Chambers. Both harvesters used a novel separation box design. Rather than locating the rotary valve (airlock) at the bottom, these valves were located at the top of each separation box. A rubber conveyor belt with cleats moved up the inclined bottom of the separation box so that as the harvested material fell out of the airstream, it was conveyed to the top and then out the rotary valve. This design was intended to use the moving airstream to help convey the material up onto the harvester, and also provided an improved separating action.

4. Cleaners. Rotary drum cleaners were used to separate the material by size. The cleaners were mounted horizontally and were driven by a sprocket which engaged a chain wrapped on the outside of the drum. Internal flighting moved the material through each cleaner. The straddle harvester had two drum cleaners, each 24 inches in diameter. The front half of each was made from perforated material having 0.31 inch diameter holes, while the rear was made from perforated metal having 0.75 inch diameter holes. The smaller harvester had one

cleaner which measured 20 inches in diameter. The front half of the cleaner was made from the same material as was used on the straddle harvester, while the rear was made using expanded metal having diamond shaped openings measuring 0.75 by 1.75 inches.

Harvester Performance

Functional Performance. Both harvesters have been extensively evaluated in commercial jojoba fields in Arizona. Speed averaged 0.52 mph for the straddle harvester, and 0.59 mph for the other unit. Theoretical field capacity for the harvesters was 1.5 ac/hr and 0.86 ac/hr, respectively, when operating in fields having a 12 ft row spacing.

The material harvested by the straddle harvester averaged 25 percent, by weight, and ranged from 12 to 40 percent. The between-the-row harvester averaged only 13 percent clean seed, with a range from 10 to 33 percent recorded. In general it was found that as field yield increased, the ratio of trash to seed decreased for both harvesters.

Component Performance. The blades and fan housings on both harvesters required replacement during the harvest season, with the boride coated fan blades outperforming the uncoated blades. A comparison of the two head designs showed the vertically oriented heads on the straddle harvester to "dig into" the soil surface, while those of the other harvester tended to "skim over" it. The separation chambers on both harvesters performed as intended, as did the cleaners. Only when a large amount of leafy material was collected with the seed did cleaner length prove to be insufficient. Under these conditions some seed was carried through the cleaner on the leaf mat, while some sand was not removed from the front half of the cleaner, and consequently was collected with the seed.

Continued Development

Although performance of the harvesters was considered satisfactory for prototypes, each requires additional modifications to make it suitable for commercial operation. The large amounts of soil and rock picked up with the seed caused excessive wear on many of the components, leading to premature failure. In order to decrease the amounts of these materials picked up additional research is underway to examine alternative head configurations using both positive and negative air flows. Results of this work are not yet complete, but preliminary indications are that significant improvements can be obtained by altering head orientation and geometry.

A development effort investigating alternative cleaning devices for use on jojoba harvesters is planned. Reduction in the amount of material now hauled from the field would significantly reduce transport costs, and would also reduce the cleaning load now placed on the processing facility.