Technical and Economic Considerations in Shipping Grass Seed Residue to Japan

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Straw stubble and aftermath residues exist as by-products of Oregon's grass seed industry, located principally in the Willamette Valley. Historically, open field burning has been a universally employed cultural practice. It provides thermal treatment for disease control and a least cost means for disposal of the residue which, to date, has had only limited market value [3]. Commercial utilization of these residues has been suggested as one of several possible adjustment alternatives which might develop to ease the stress of economic adjustment for grass seed producers as they face a January 1, 1975, legislative deadline for termination of open field burning. Removal of straw residue and its conversion to a marketable product are perceived as potentially important farm practices, if commercial markets can be identified and straw residue can successfully compete in them [4,5].

In February 1972, Governor McCall's Oregon Trade Mission to Far Eastern countries initiated an exploratory effort to determine the prospects for shipping grass residues from the Pacific Northwest to Japan for livestock feed. The Governor reported that considerable interest was expressed by the Japanese in receiving grass seed residue for livestock feeding purposes. Consumer demand for red meats in Japan is increasing, attributable, in part, to changing tastes and preferences and increased incomes. Some shifting of field crops to provide feed for dairy, beef, and poultry production has already occurred. However, limited land area in Japan suggests that supplemental feeds from external sources may be needed.

But Japan's need for supplemental feeds may be quite different from ability and willingness to pay which form the basis for effective market demand. And the ability for grass seed residue to successfully compete in either foreign or domestic markets requires as necessary conditions that certain mutually interdependent technical and economic feasibility criteria be met.

Technical Issues

Technical feasibility is a precursor to economic feasibility. The nature and composition of grass seed straw is an important technical consideration. Chemical analysis, feeding experiments, and utilization efforts indicate that grass residue has several unique characteristics. Grass straw, generally speaking, is high in cellulose and lignin fibers (30 to 40 percent) and low in protein (2.5 to 5 percent). This suggests that grass residue may be a good source of fiber for rumen stimulation and wintering rations for livestock. Low protein and carbohydrate levels may preclude grass residue use for growth and fattening rations unless these constituents are supplemented from other feed sources. In addition to livestock feeding, several other uses exist for fiber from grass residue. These include its use as a raw material source in making paper products (newsprint, fine papers, corrugating medium, fiberboard, particleboard, and hardboard), oil, gasoline, plastics, and microbial protein. Straw as a mulching material has also been suggested.

Economic Issues

Technically speaking, many alternatives for grass residue utilization exist. When subjected to economic consideration, however, the prospects appear to be more limited. In both domestic and international markets, the ability for grass straw to be commercially utilized is based on its ability to compete with alternative feed and fiber raw material sources. Demand and supply considerations influence this capability. Relative prices and utilization characteristics of alternative raw material sources form the basis for determining grass residue's competitive position.

What are the relevant demand and supply relationships which will affect possible grass residue utilization in the Japanese livestock feeding market? On the demand side, it is highly unlikely that grass seed residue will compete against alfalfa hay in the forage market. Difference in feed quality and price will be major determinants. The Western United States supplied over 400,000 tons of cubed and pelleted alfalfa hay to Japan in 1971. This alfalfa comes primarily from Eastern Washington and Oregon, California, and Arizona [10]. During 1972, alfalfa pellets were delivered to Seattle, Tacoma, and Portland ports at $35 to $55 per ton F.O.B. for export to Japan [11]. Sun-cured pellets ranged from $35 to $48 per ton while dehydrated pellets were $40 to $55 per ton [2]. To compete, grass residue straw would have to be priced substantially below the price of alfalfa to account for its relatively lower feeding qualities. Just how much less the price must be depends on whether the straw is perceived by Japanese livestock producers as a fiber source or as a forage source the relative price and feeding qualities of alternative feeds used in Japan and shipping rate differentials established for various feed classes. Recent evidence suggests that straw is being viewed primarily as a fiber source. Japan buys mill feed pellets from Canada and Argentina as a fiber source and has made contact with several Middle Eastern countries as potential suppliers of sugar cane fiber. Unfortunately, specific information on the types of markets and prices required for grass seed residue to compete effectively in them is not known [2,12]. Communications with Zenrakuren in November 1972 indicate that grass residue is being used as a fiber source for dairy rations in Japan [12]. Zenrakuren is Japan's largest dairy cooperative and apparently sole distributor of grass seed residue shipped to Japan for feeding trials. The rations used call for about one-half of the fiber source to come from grass seed residue. Beet pulp and rice straws account for the remainder. By weight, fiber or roughage sources account for 40 to 50 percent of the rations.

On the supply side, costs associated with entry of grass seed residue into the Japanese forage market are important. These costs include field removal, densification, transport, and storage costs from the field to on-dock delivery in Japan. If these costs are fully covered at the market prices which Japanese buyers are willing to pay, then economic conditions will have been met to permit grass residue entry into these potential markets.

However, satisfaction of technical and economic feasibility criteria is not necessarily sufficient to assure market entry of grass residue. Institutional, political, and socio-economic criteria, to the extent that they affect grass residue utilization, also need to be considered and their effects evaluated before significant commercial utilization of grass residue in the Japanese market can become a reality.[1/]

Study Objectives

Technical and economic data from recent Oregon State University research studies identify costs of field removal, densification, storage, and hauling alternatives for accommodating grass seed residue in Pacific Northwest markets. The scope, viability, and competitive nature of forage markets for livestock feeding in Japan and the technical and economic requirements of shipping grass seed residue into those markets have not yet been determined [5]. This study is directed toward the latter issue.

The objective of this study is to determine the technical and economic requirements of shipping grass seed residue in selected densified forms from grass seed fields in the Willamette Valley to dockside Japan and evaluate their relative merits.

Procedure

Identification of the technical requirements of shipping grass seed residue in selected densified forms involve review of: (1) alternative handling choices; (2) on-dock and on-shipboard storage requirements; and (3) physical attributes which affect handling and storing of grass residue, both in the Pacific Northwest and in Japan. On the economic side, attention is directed to specification of costs of densification, handling, storing, and transporting of residues in several densified forms, followed by a comparison of these choices.

[1/] International shipping rates, duties or tariffs, and agricultural production policies within foreign countries are examples of policy instruments which can be modified to provide an economic climate either favorable or unfavorable for U.S. commodities competing in international markets. Health standards affecting chemical residue tolerances in feeds are examples of institutional forces which can affect both domestic and foreign utilization of grass residue.

Field removal and densification costs were obtained from research work conducted by Oregon State University and from selected secondary sources. Transport, storage, ocean freight, and handling charges were obtained from direct interview with port, brokerage, and export marketing personnel having trade relations with Far Eastern countries.

Alternative Means of Densification

Bulkiness of straw residue dictates that it be densified to facilitate handling and reduce costs where commercial utilization and long distance hauls are involved. The appropriate form of densification depends upon the market for which residues are destined, length of haul, commerce regulations, and available handling facilities both enroute and at final destination. The densified forms selected for comparison in this study include:

Form of Densification	Average Bulk Density[2/]
Standard Bale..........................	6-8 lb./cubic foot
High density or high compaction bale....	10-14 lb./cubic foot
Super high density bale................	32-36 lb./cubic foot
Cubes..................................	18-25 lb./cubic foot[3/]
Pellets................................	35-45 lb./cubic foot

Standard Bale

Field baling is the most commonly used commercial means for forage densification. Bales weighing 60-90 pounds most commonly are produced. An average bulk density of 6 to 8 pounds per cubic foot is expected when grass residue is baled. Both string and wire tie bales are used. For overseas shipment, greater bale breakage is anticipated with string tie

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[2/] The bulk densities listed represent estimates of the most typical range of average densities expected for grass seed residue. Estimates were supplied by Glen Page, Associate Professor of Agricultural Engineering, Oregon State University, Corvallis.

[3/] Average bulk densities of 30 to 35 pounds per cubic foot from cubes have been achieved in laboratory tests indicating that this level is technically feasible. No commercial units have achieved this capacity, however.

bales in transit. On the other hand, greater care must be taken in removal of wire at feeding sites for wire tie bales [2].

High Density Bale

The high density or high compaction bale is similar to the standard bale except that a slightly higher compression by the field baler produces a bale which is compressed tighter, is slightly larger, weighs more than the regular bale, and is tied with three wires. Bales range in weight from 90 to 150 pounds.

Super High Density Bale

An exploratory research effort in 1971 by the Department of Agricultural Engineering, Oregon State University, established the technical feasibility for making super high density bales. This process is being developed and commercialized by HASTRO-WEST, of Brownsville. The process employs a large hydraulic press within which chopped or baled straw residue is placed for further compaction. A bale approximately 3 feet x 4 feet x 4 feet in size and weighing some 1600 pounds, with a bulk density of 32 to 36 pounds per cubic foot is produced. At this stage, it is perceived that standard baling in twine bales will be the method used for field removal and hauling to the stationary super high density bale machine. Whether the Japanese transportation and livestock feeding industries can accommodate this form of straw densification is not known definitively although trial shipments in 1972 suggest that it may be promising.

Cubes

Densification by cubing may be accomplished by portable field cubers or stationary cubing machines. Either method produces cubes approximately 1-1/4 inches square and 2 to 3 inches long with a bulk density of 18 to 25 pounds per cubic foot using grass residue. A binder must be added to prevent the cube from crumbling or breaking apart.

Field cubers pick up the residue from windrows, chop the straw, cube it, and convey the cubes into a field wagon for transport to unloading or on-farm storage sites. The binder is carried in a tank on the cuber or in a truck which moves alongside the cuber. Field cubing is curtailed by heavy dew and/or rainy conditions. Since residue removal must precede post-harvest thermal sanitation, a time limitation is imposed by fall rains which commence in September or October. Normally a 50 to 65-day harvest season is available within which grass seed harvest, residue removal, and thermal sanitation must be accomplished.

Stationary cubing requires that the straw is first baled or chopped in the field, then hauled to a storage site near the cubing unit. The field option choice of baling or chopping straw for use with the stationary cuber is expected to vary depending on individual operator needs, machine availability, machine costs, and time available after harvest for cubing. The stored straw can be cubed throughout the year or on a demand basis. Inclusion of either binders or feed additives is facilitated with stationary cubing units. Tanks for binders and feed additives provide flexibility of operation, particularly where a wide range of additives is required to meet a variety of market specifications. The stationary cuber can mix binders and additives with the straw and also mix low quality straw with higher quality straw providing potential for greater uniformity and feed mix versatility than with field cubes. A drier unit will be required with stationary cubing if continuous production of high density cubes during the rainy and high humidity months in the Willamette Valley is desired.

Pellets

The pelleting process is similar to that involved in making cubes. The straw is baled, hauled from the field to a storage site, and pelleted by a stationary unit at any time during the year. Pelleting dies permit a range in pellet size from 1/4 inch to 5/8 inch in diameter and from 1/2 inch to 1-1/4 inches in length. With pellets, no binding agent is necessary since heat and pressure in the pelleting process is sufficient to assure adequate binding. The heat treatment also kills weed seeds and disease pathogens. Feed additives such as urea may be included with straw residue prior to pelleting to alter its feed composition. The required chopping or grinding of the residue prior to pelleting results in a short fiber length. This makes pellets less attractive than cubes as a source of fiber in feed rations for rumen stimulation. Heat generated in the pelleting process likely will be sufficient to preclude the need for a separate drier unit as required with cubes. However, sufficient time is essential in cooling the pellets prior to shipment in enclosed containers to avoid surface mold.

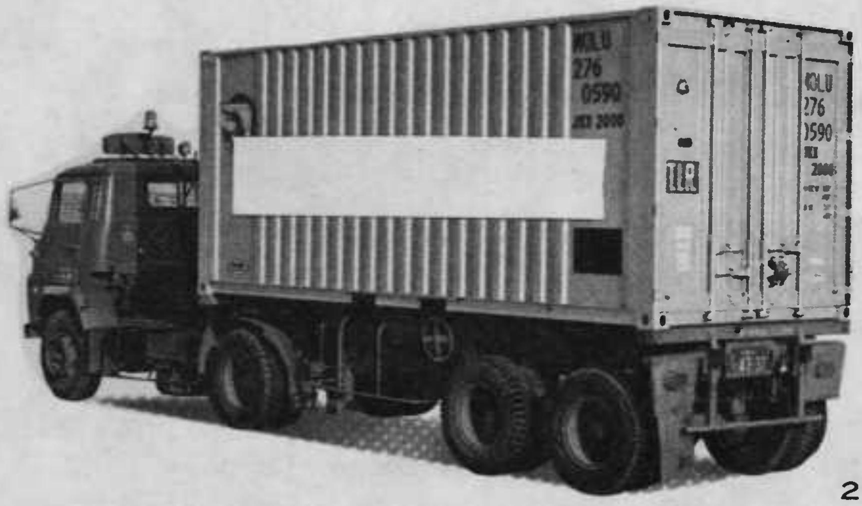
Handling Choices for Overseas Shipment

Grass residue for overseas shipment may be handled either in bulk form or in containers. Bulking involves direct cargo shipment in the hold of ocean vessels. Container shipment requires the cargo to be loaded first into a container, which is then loaded into the hold of a ship.

Containerization

Overseas containers are large steel and/or aluminum units of 20 or 40 foot lengths which, with assistance of cranes, may be temporarily mounted on semi-trailers for highway transport. Figure 1 shows both steel and aluminum containers mounted on highway trailers. With appropriate facilities, containers may be filled either at dockside, or at field sites, then returned to dockside by rail or commercial highway carriers.

Four types of containers currently are available to accommodate overseas shipment of grass seed residue. They are dry, bulk, open top, and flat rack containers. The bulk and dry containers are similar. The dry container has only rear access doors. Bulk containers have access hatches on top and in the rear. The top hatches and discharge chute near the bottom of the rear doors facilitate mechanical loading and unloading of cubes and pellets. Dry container tare weight is approximately 1340 pounds lighter than the bulk container, permitting a slightly greater payload. Open top containers have no structural cover. This makes them suited for loading and unloading standard bales or super high density bales by forklift equipment unencumbered by height limitations. Cubes and pellets also can be shipped in this form. A tarpaulin is used to cover the container during inclement weather. If moisture absorption enroute overseas is an important consideration, then both dry and bulk containers are preferable to open top containers. The flat rack container is essentially a flatbed trailer with removable side racks. This container, like the open top type, is suited for products which are palletized or necessitate forklift equipment, such as standard high density or super high density bales. This container is equipped with a tarpaulin to protect the load from



20′ DRY (STEEL) CONTAINER

20′ DRY ALUMINUM CONTAINER

FIGURE 1. Containers mounted on highway trailers for overseas shipping.

inclement weather but would not protect against moisture absorption caused by high humidity levels.[4/]

Highway transport by truck-tractor units permits containers to be taken directly to individual farms and/or processing plants for straw residue loading. Containers shipped by rail require residue to be transported from the field or processing plant to railheads where the container is filled on the flatcar. Lack of equipment at railheads precludes removal of containers from flatcars. The Interstate Commerce Commission (ICC), which regulates U.S. commercial highway trucking, sets gross weight limits of 78,000 pounds on 52-foot truck-trailers and 73,250 pounds on 40-foot semi-tractor trailer units [9]. This restricts highway payloads to a maximum of 20 to 23 tons of grass residue. Higher gross weight per container is permitted with rail haul than with commercial truck hauls.

Approximate dimensions for overseas containers are shown in Table 1. Dimensions will vary somewhat depending on the manufacturer and the material used in container construction. Maximum gross weight limitations for ocean hauling are established by the International Maritime Commerce Commission. The gross weight limit is 67,200 pounds for 40-foot containers and 44,800 pounds for 20-foot containers. This includes the payload and tare weight of the container. The tare weight will vary by container type, construction of container, and the form in which grass residue is densified. Payload capacities for 20 and 40-foot containers are shown in Table 2. Approximately 20 and 30-ton payload limits for 20-foot and 40-foot containers respectively are permitted by IMCC regulations. Pellets are the only densified form using 20-foot containers which could be restricted by ICC weight limitations for highway trucking in the U.S. Rail shipment of containers to dockside would overcome this limitation and permit some 25 tons of pellets per container to be hauled. If 40-foot containers prove feasible for Japanese conditions, then only standard and high density bales could be transported without being subjected to either ICC or IMCC weight limitations. The super high density bales,

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[4/] Grass residue in cubed and pelleted forms will deteriorate and collect mold upon exposure to moist or humid conditions. Humidity in excess of 15 percent causes the product to expand and crumble [5].

TABLE 1. Dimensions and Load Capacities of Selected Dry Freight Containers For Overseas Shipment

	40' Aluminum	20' Aluminum	20' Steel
Outside Dimensions:			
Length.............	40'0"	19'10-1/2"	19'10-1/2"
Width...............	8'0"	8'0"	8'0"
Height..............	8'6"	8'0"	8'0"
Inside Dimensions:			
Length..............	39'7"	19'5-1/2"	19'4-7/16"
Width...............	7'8-1/2"	7'8-1/2"	7'8-1/16"
Height..............	7'10-5/6"	7'5"	7'5"
Inside Capacity..........	2,401 cu. ft.	1,114 cu. ft.	1,100 cu. ft.
Tare Weight..............	6,260 lbs.	3,400 lbs.	4,560 lbs.
Max. Gross Weight........	67,200 lbs.	44,800 lbs.	44,800 lbs.
Max. Payload.............	60,940 lbs.	41,400 lbs.	40,240 lbs.

SOURCE: MOL Container Guide, Mitsui O.S.K. Lines, c/o Williams, Dimond and Company, Seattle, Washington.

TABLE 2. Physical Capacity of Containers for Grass Seed Residue in Selected Densified Forms

	20' Containers	40' Containers
Standard Bale..................	3.3 to 4.4 tons	7.2 to 9.6 tons
High Density Bale...............	5.5 to 7.8 tons	12 to 16.8 tons
Super High Density Bale.........	17.6 to 20 tons	30.47 tons[b/][c/]
Cubes..........................	9.9 to 13.9 tons	21.6 to 30 tons[b/]
Pellets........................	19.2 to 20.7 tons[a/]	30.47 tons[b/][c/]

[a/] Payload weight limitation of 20.7 tons is imposed by ICC highway freight regulations. The full 25-ton payload could be shipped by rail.

[b/] ICC highway freight limitations of 20 to 23 tons net payload permit only the rail hauling choice to be used from the field to dockside departure point for overseas shipment.

[c/] Container weight limitation imposed by IMCC ocean freight regulations.

cubes, and pellets shipped in 40-foot containers would have to be transported to dockside by rail to avoid ICC limits. The super high density bales and pellets shipped by rail in 40-foot containers would be limited to a payload weight of 30 tons by IMCC restrictions.

Bulking

Ocean shipment of grass seed residue in bulk form can be accommodated in two ways. One involves bulk cargo and the other involves "break bulk" cargo shipment. Bulk cargoes refer to those types which can be poured, dumped, or are free-flowing into ocean vessels such as grain, pellets, and cubes. Break bulk cargoes refer to those types which require handling by labor and/or machines for loading and stowing aboard vessels. Standard bales and bales which are strapped and palletized fall into the break bulk category. Handling is an important cost component for break bulk shipments. In the case of baled straw, it must first be freighted to Portland by truck or train, unloaded from the carrier, palletized, then loaded onto the ship by cranes. Pallets are stacked in the ship's hold by a lift truck or the bales are taken from pallets and stacked by hand. Fire hazard considerations dictate minimizing on-dock storage in the transfer of bales from truck to ship's hold [2]. Break bulking of standard straw bales is time consuming and bales often are broken.

When pellets or cubes are shipped bulk, they are usually placed in grain elevators or dumped in large warehouses, then transferred from these facilities to the ship's hold by means of conveyors. Pellets and cubes are subject to crumbling with conveyor and pneumatic handling. In Portland, grain shipments fully utilize existing elevators leaving no facilities available for handling of cubes or pellets. Currently, Astoria is the nearest port to accommodate cubes and pellets in bulk form from the Willamette Valley [1].

Economic Costs of Densification, Handling, and Shipping

The cost analysis of this study is separated into two categories: (1) costs associated with field removal and delivery of grass residue to dockside Portland, and (2) costs associated with shipment of grass residue from dockside Portland to dockside Japan. This separation facilitates review of costs associated with movement of grass residue in domestic markets as well as identification of the special costs associated with shipment of grass residue to Japan.

Costs From Field to Dockside Portland

Field removal, densification, and on-farm storage costs were obtained from primary research sources at Oregon State University and other West Coast universities and supplemented with secondary source information for custom rates and case study costs. A range of costs are quoted to reflect the scope of average expected costs for the grass seed industry under varying sets of conditions. Since no definitive market has yet been established for grass residue, no attempt is made to include an estimated field value for it in the cost analysis. Table 3 summarizes the cost components for each of five densification choices in transfer of grass seed residue from field to dockside Portland.

Comparison of alternative densified forms from Table 3 indicate that considerable cost variation exists. The combined cost of field residue removal, densification, storage, and transport to Portland ranges from $14 to $40 per ton. Low cost choices are standard bales and cubed straw from a field cuber resulting in costs which range from $14 to $29 per ton delivered in Portland. On the high cost side are pelleting and stationary cubing with costs ranging from $21 to $40 per ton. While field cubing shows a cost advantage over stationary cubing, the low cost range on field cubing assumes field utilization somewhat in excess of the normal 50 to 65-day harvest period, unless the cuber is treated as a stationary unit for off-season cubing, in which case additional densification, hauling, and equipment costs would be required.

Absolute magnitude of cost is not the sole consideration in determining which densification process, if any, is selected. If markets for grass residue become a reality in the Pacific Northwest, the densification form must be amenable to handling and utilization requirements of the commercial organization which uses grass residue as a raw material source. While residue in baled form may be acceptable for certain types of livestock feeding, its use in other commercial areas may dictate that it be cubed or pelleted to permit handling by conveyor, pneumatic, or other mechanized

TABLE 3. Costs Per Ton From Field to Dockside Portland For Grass Seed Residue in Selected Densified Forms

	Cost range
For Baled Straw (regular and high density bales):	
Swath (custom $3-$5 per acre) a/b/	$ 1.70 to $ 3.00 per ton
Bale (custom) a/	5.00 to 7.00 per ton
Haul bales to on-farm storage a/	3.00 to 5.00 per ton
Haul to Portland c/	4.00 to 6.00 per ton
TOTAL	$13.70 to $21.00 per ton
For Super High Density Bale:	
Swath, bale, and haul to on-farm storage	$ 9.70 to $15.00 per ton
Compress into the super bale d/	5.00 to 12.00 per ton
Haul to Portland	4.00 to 6.00 per ton
TOTAL	$18.70 to $33.00 per ton
For Cubed Straw:	
By stationary cuber with baler for field removal:	
Swath, bale, and haul to on-farm storage	$ 9.70 to $15.00 per ton
Cubing of baled straw e/	5.50 to 13.00 per ton
Binder f/	1.00 to 4.00 per ton
Drying g/	.60 to 1.50 per ton
Haul to Portland	4.00 to 6.00 per ton
TOTAL	$20.80 to $39.50 per ton
By stationary cuber with chopper for field removal:	
Swath (custom $3-$5 per acre)	$ 1.70 to $ 3.00 per ton
Field chop and haul to on-farm storage h/	10.00 to 15.00 per ton
Cubing of chopped straw e/	3.50 to 11.00 per ton
Binder	1.00 to 4.00 per ton
Drying	.60 to 1.50 per ton
Haul to Portland	4.00 to 6.00 per ton
TOTAL	$20.80 to $40.50 per ton
By Field Cuber:	
Swath (custom $3-$5 per acre)	$ 1.70 to $ 3.00 per ton
Field cubing and haul to on-farm storage i/	7.00 to 16.00 per ton
Binder	1.00 to 4.00 per ton
Haul to Portland	4.00 to 6.00 per ton
TOTAL	$13.70 to $29.00 per ton
For Pellets:	
Swath, bale, and haul to on-farm storage	$ 9.70 to $15.00 per ton
Stationary pelleting j/	10.00 to 16.00 per ton
Haul to Portland	4.00 to 6.00 per ton
TOTAL	$23.70 to $37.00 per ton

(Footnotes on following pages)

[a] Custom rates for hauling, baling, and swathing were obtained from A. Gene Nelson and David Miller. "Custom Rates for Farm Machinery in the Oregon Columbia Basin Counties," Extension Special Report 360, Oregon State University, Corvallis, May 1972.

[b] Custom swathing is quoted on a per acre basis. Conversion to a per ton basis is a function of residue volume. Residue yield levels were obtained from estimates by the Department of Agronomic Crop Science, Oregon State University, Corvallis and were quoted in "Farmer Alternatives to Open Field Burning: An Economic Appraisal," by Frank S. Conklin and R. Carlyle Bradshaw, Agricultural Experiment Station Special Report 336, Oregon State University, Corvallis, October 1971. The $1.70 per ton assumes 3 tons of residue removed at a custom rate of $5 per acre while the $3 per ton assumes 1 ton of residue removed at a custom rate of $3 per acre. Some residue must remain on the field for thermal sanitation.

[c] Based on expected non-commercial agricultural haul rates. If commercial freighting is used, particularly with containers, the rates could be somewhat higher. Commercial freight rate estimates for Mid-Willamette Valley sites were obtained from Mike McKillip of Williams, Dimond and Company Portland, and Lyle Turnbull, Southern Pacific Transportation Company, Portland. Trucking rates were quoted at $115 per container or approximately $6 to $12 per ton depending upon the form of densification. Railroad rates were quoted at $6.40 to $7 per ton with a 57.5 ton minimum load.

[d] A high compression unit is used to press chopped or baled straw into a 1600-pound bale measuring 3'x4'x4'. Preliminary data are available from Hastro-West. The quoted range in custom rates must be viewed as highly tentative. Preliminary estimates indicate that the capital investment for a high compression unit and allied facilities would be at least $100,000. With an assumed life of 5 years because of high obsolescence potential, interest on average investment of 9 percent, repairs at 10 percent of average investment, and taxes and insurance at 2-1/2 percent of average investment, the annual ownership cost would approximate:

Depreciation........	$20,000	
Interest............	4,500	
Repairs.............	5,000	
Taxes & Insurance...	1,250	
	$30,750	per year

With operating costs estimated at $25 per hour for power and labor for 3 to 4 skilled employees and $2.50 per ton for steel banding, and estimated average output rate ranging from 5 to 10 bales per hour, the following cost structure emerges for varying annual levels of production:

Annual production	Cost per ton: At 5 bales or 4 tons/hour	Cost per ton: At 10 bales or 8 tons/hour
5,000 tons......................	$12.40	$ 9.27
10,000 tons......................	9.33	6.20
15,000 tons......................	8.30	5.17
20,000 tons......................	7.79	4.66

(continued)

e/ Estimates on cubing of baled or chopped straw were obtained from Philip S. Parsons, John B. Dobie, and Robert G. Curley, "Alfalfa Harvesting Cost: Baling, Field Cubing, and Stationary Cubing." AXJ 346, Agricultural Extension Service, University of California, Davis, March 1971. The cost range reflects varying levels of output. The high cost quotation represents 1000 tons, while the low cost represents 10,000 tons of annual output per cubing unit. The $2 per ton higher cost for cubing of baled vs. chopped straw represents the estimated cost of stationary chopping of bales immediately prior to the cubing operation.

f/ Binders or sticking agents such as ammonium lignin sulfonate are required with cubing to assure adequate bonding. Molasses, urea, and other feed additives may be included to improve digestibility and palatability of the product for livestock feed. Only a charge for binder was included in the cost estimate for this study.

g/ Drier costs were obtained from Mr. Andrew Boardson of Red Crown Mill Supply Co., Portland. A capital investment for a used gas-fired boiler drier is $25,000, inclusive of wiring, motors, and installation. The unit is 8 feet in diameter and 24 feet long. It is capable of evaporating 1500 to 2000 pounds of water per hour from 6 to 8 tons of straw. With an assumed useful life of 10 years, interest on average investment of 9 percent, repairs at $1000 per year, and taxes and insurance at 2-1/2 percent of average investment, the annual ownership costs are estimated to be:

Depreciation........	$ 900
Interest............	500
Repairs.............	1000
Taxes & Insurance...	130
	$2530 per year

Operating costs for gas which requires 2000 BTU's per pound of evaporation total $3 per hour using natural gas, and $6 per hour with propane. Drier costs per ton for varying levels of annual production are:

Annual production	Cost per ton: 6 tons/hour with propane	Cost per ton: 8 tons/hour with natural gas
1,000 tons......................	$3.53	$2.90
5,000 tons......................	1.50	.90
10,000 tons......................	1.25	.65
15,000 tons......................	1.17	.57
20,000 tons......................	1.13	.53

h/ The estimated range in custom rates for use of a chopper-blower and wagon or stackformer equipped with chopper unit was obtained from California and Wyoming data. California custom rates were obtained from A. Doyle Reed, "Custom Rates for Farm Operations," MA 21, Agricultural Extension Service, University of California, Davis, March 1970. Wyoming custom rates were obtained from Delwin M. Stevens, "Wyoming's Farm Custom Rates 1969." Agricultural Experiment Station Bulletin 512, University of Wyoming, Laramie, February 1970.

(continued)

i/ Estimates on field cubing and hauling to on-farm storage were obtained from Dan M. Newman and Robert C. Angus, "Cost and Profit Comparison of Baling and Cubing Alfalfa Hay," in Progressive Agriculture in Arizona, May-June 1970, and Philip S. Parsons, John B. Dobie, and Robert G. Curley, "Alfalfa Harvesting Costs: Baling, Field Cubing, and Stationary Cubing," AXJ 346, Agricultural Extension Service, University of California, Davis, March 1971. Technical feasibility under Oregon conditions has not yet been demonstrated. Minimum annual machine use of 1000 to 3000 tons per year are required to achieve the cost levels quoted. With an assumed field rate of 4 tons per hour, a 25 to 75-day use session is required.

j/ Stationary pelleting costs were obtained from personal communication with Richard Berger [1] and Wayne Peterson [11] who received their cost estimates from commercial units in Oregon and Washington. These were verified with an unpublished case study of stationary pelleting costs for 30,000 to 52,000 tons of annual output prepared by Tom Norton for a class in Agricultural Economics, Oregon State University, Corvallis, Summer 1972. The case study indicated that while lower than $12 per ton costs could be achieved, operation at plant capacity throughout the year would be required.

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processes. For overseas shipment, addition of overseas freight and handling charges discussed in the next section must be made. For domestic markets, increased densification and its associated higher costs are not offset by lower transportation charges per unit hauled since ICC weight restrictions limit the exploitation of transportation economies.

Costs From Dockside Portland to Dockside Japan

Specifocean freight and handling charges for grass seed residue are difficult to establish. Ocean freight rates are set by the Pacific Westbound Shippers Conference whose members include steamship companies shipping between the Far East and the U.S. West Coast. Since grass seed residue has not been shipped overseas in large quantities, common ocean freight rates have not yet been established for it. Unlisted commodities, until a specific rate is established, carry a general rate of approximately $84 per ton [7]. This rate is more than twice the rates of $30.62 per ton charged for overseas shipment of baled hay and $38.50 per ton for alfalfa cubes or pellets shipped break bulk [2]. Consequently, it is assumed, for purposes of this study, that grass seed residue rates will not exceed the existing established rate on alfalfa hay. If they did, certainly no opportunities would exist for grass residue to compete with other forages currently being shipped. On the other hand, if grass residue becomes classed as a fiber source with a feeding value less than alfalfa hay, then a special lower cost rate might be established. The rates quoted by the Pacific Westbound Shippers Conference appear to be maximum allowable ones and individual steamship companies do alter their rate structure to account for special circumstances of product type, form of shipment, opportunities for two-way haul, seasonal supply pressure on containers and vessels, and international balance of payments. Ocean freight charges are presented in Table 4. A comparison of the costs reveals that transportation economies exist in ocean freight with increased residue densification. Pellets had the lowest total ocean freight charge of $14.50 to $23.50 per ton, while standard bales had the highest with $37 to $39 per ton. Explanation of specific cost items is presented in the following sections.

Ocean Freight. Steamship companies view the container price for ocean freight as being negotiable. An excess supply of containers on the West Coast and a shortage of containers in Japan often result in renegotiation of the rate level rather than dead-heading (empty return) of containers. Container rates for ocean freight appear to range from $220 for a 20-foot container filled with hay cubes to $300 when filled with pellets [10]. The 20-foot container holds 10 to 14 tons of cubes and 19 to 20 tons of pellets. This converts to $16 to $22 per ton for cubes and $15 to $15.80 per ton for pellets for ocean freight. Rates have not been listed for shipment of cubes and pellets in 40-foot containers since it is doubtful that the Japanese will permit 40-foot containers to be trucked on their highways. Expected ocean freight rates for the super high density bale are equally uncertain. For this study, the previously quoted rate of $220 to $300 per container will be assumed to be appropriate for them. If correct, the ocean rate for the super high density bale would be from $11 to $15.60 per ton.

The ocean freight rate for bulk shipping also appears to vary widely by the type of commodity being hauled and the availability of ships and dock facilities available to accommodate this method of haul. The present rate for shipping pellets bulk is estimated at $10 to $11 per long ton or approxi-

TABLE 4. Cost Per Ton (2000 pounds) From Portland to Japan for Grass Seed Residue in Selected Densified Forms

Densified form	Method of shipping	Ocean freight	Bunker surcharge	Currency surcharge	Wharfage & handling	Miscellaneous[a]	Total
Bale...........	In Container	$30.62[b]	$1.78	$3.24	$1.25	$.20[c]	$37.09
	Bulk	30.62	1.78	3.24	3.35	.20	39.19
Super High Density Bale....	In Container	11.00 to 15.60	1.78	1.28 to 1.74	4.14[e]	.20	18.40 to 23.46 f/
Cube...........	In Container	15.70 to[d] 22.00	1.78	1.75 to 2.38	4.14[e]	.20	23.57 to 30.50 g/
	Bulk	19.00 to[d/h] 24.50	1.78	2.08 to 2.63	4.50 to 5.00	.20	27.56 to 34.71
Pellet.........	In Container	15.00 to 15.80	1.78	1.68 to 1.76	4.14[e]	.20	22.80 to 23.68 h/
	Bulk	9.00 to[i] 10.00	1.78	1.08 to 1.18	2.50	.20	14.56 to 15.66

[a] Included are insurance, brokerage, and documentation charges. These costs are charged on a flat fee basis or on a fixed percentage of cargo value.

[b] The ocean freight rate for baled alfalfa hay, as agreed upon by the Pacific Westbound Shippers Conference, is $30.62/ton regardless of the form in which it is shipped. However, it is extremely doubtful that any baled grass residue will be shipped in containers unless the rate is changed since a container holds only 4 tons of baled straw. At the $30.62/ton rate, the container rate becomes $122.48, a price considerably below steamship quoted rates of $220 per container.

[c] Estimated cost for insurance and documentation fees. A value of $20 to $30 per ton dockside Portland was assumed for insurance purposes. No brokerage charges were included in the calculation.

[d] The quoted ocean freight rate for cubed alfalfa hay shipped bulk is $38.50/ton. However, current container and bulk rates appear to be considerably below the quoted ones and were used for this study.

[e] Wharfage of $.79 per short ton plus $3.35 per short ton for ocean carrier handling at dockside.

[f] Several steamship companies have quoted a minimum container rate of $220 to $300 depending upon the density of the product. Bunker and currency surcharges are included in the rate. If a $250 rate were used for the super bales, the total cost is reduced to approximately $15.50 to $20.00 per ton.

[g] Several steamship companies have quoted a minimum container rate of $220 for cubes which includes bunker and currency surcharges. If this rate is used, the total cost is reduced to approximately $20 to $26.50 per ton.

[h] Several steamship companies have quoted a minimum container rate of $300 for pellets which includes bunker and currency surcharges. If this rate is used, the total cost is reduced to about $20 per ton.

[i] Bulk ocean rates on cubes and pellets assume a minimum of 1000 tons per shipment. If the shipments range from 4 to 6 thousand tons, the rate will decrease by approximately $1 per ton. If the shipment is to exceed 10,000 tons, rates will decrease by about $2 per ton.

mately $9 to $10 per short ton (2000 pounds). This assumes that current bulk rates on pellets are the same as those used for Pacific Northwest grains shipped to Japan. Using this rate structure, the bulk rate for cubes would be $10 to $24.50 per short ton [1].

Other Ocean Haul Charges. In addition to direct ocean freight, other services are required to accommodate overseas shipping. These include a bunker surcharge, international currency exchange, on-dock handling and storing (wharfage charges), load and trip insurance, brokerage service, and load documentation [8]. Bunker, currency exchange, and wharfage charges are affected by the form in which grass seed residue is densified and whether it is handled shipboard in container or bulk forms.

The bunker surcharge is assessed to cover increased costs for fuel used by the ocean vessel. The bunker surcharge is $2 per long ton or $1.78 per short ton (2000 pounds) and is required for straw residue shipped either in container or bulk forms. Some shipping companies include the bunker surcharge in the quoted ocean freight rate.

The wharfage fee is the dock's handling charge. It is assessed on all cargo that moves across the dock in accordance with the terminal tariff applicable. It is a required cost for any commodity being loaded or unloaded and varies with the type of commodity and the nature of the loading requirement. The base rate is $1.25 per short ton when applied to baled residue which covers use of the docks and on-dock storage for two weeks. A wharfage charge of $.79 per short ton is applicable on bulk commodities loaded in containers such as pellets, cubes, etc. Containers loaded at dockside by the ocean carrier are charged $3.35 per ton for handling, in addition to the wharfage charge. Baled residue shipped break bulk is also charged a $3.35 per ton wharfage fee instead of the usual $1.25 because of its low bulk density and high fire hazard risk. Cubed residue shipped bulk carries a wharfage fee of $4.50 to $5 per ton while pellets are charged $2.50 per ton [8]. Some 20 to 25 containers per hour can be loaded shipboard from dockside with existing equipment regardless of container type. Thus, 60 to 80 tons of baled hay, 180 to 260 tons of cubes, and around 400 tons of super high density bales and pellets could be loaded shipboard per hour. Break bulk loading of bales on shipboard is limited to 5 to 10 tons per hour. Bulk loading shipboard by elevator or pneumatic conveyors permit a rate of 60 to 70 tons per hour for cubes and 400 to 500 tons per hour for pellets with present facilities [1]. Some problems of conveyor clogging may be encountered.

The currency surcharge accounts for international exchange rate differentials between nations. For Japanese bound cargo, the surcharge is 10 percent of the combined ocean freight rate and bunker surcharge. In some cases, the currency surcharge is included in the quoted ocean freight charge, especially when Japanese containers and ocean vessels are used.

Other costs of international freight shipments which do not influence the decision of which densified form of ocean freight method is most economical include insurance, brokerage charges, and documentation charges [8]. Ocean freight insurance is 60¢ per $100 of value when shipping to Japan and most Far East countries, exclusive of the Viet Nam zone. Brokerage charges vary widely. Some brokers charge a flat rate for each shipment no matter how large or how small the shipment, while others charge by bill of lading. Some shipping companies provide brokerage services with their rates included in the ocean freight charge. A $4.50 documentation charge is required per shipment to cover fumigation and straw inspection to insure that the straw is of acceptable quality.

<u>Comparison of Total Cost From Field To Japan</u>

A review of total costs from field to Japan is presented in Table 5. With exception of the pelleted form, densified grass residue shipped in container form has a net cost advantage of $5 to $7 per ton over shipment in bulk form. Field cubes and the super high density bales shipped in container form emerge as the lowest cost choices. However, lack of technical data on the super high density bale and limited operational season for the field cuber suggest that considerable caution be exercised in interpreting cost data for these densified forms.

If large quantities of grass seed residue were exported, the costs associated with bulk shipments would probably decline. Ocean shipping companies have implied that rates for bulk shipments in excess of 1000 tons would be lowered. Development of bulk handling facilities in Portland

TABLE 5. Total Cost Per Ton (2000 pounds) of Grass Residue From Willamette Valley Fields to Japan in Selected Densified Forms

Densified form	Method of shipping	Total cost to dockside Portland	Shipping cost to Japan a/	Total cost to dockside Japan
Standard bale......	In container	$-------------	$-------------	$------------- b/
	Break Bulk	13.70 to 21.00	39.19	52.89 to 60.19
Super high density bale.......	In container	18.70 to 33.00	18.40 to 23.46	37.10 to 56.46
	Break Bulk c/	-------------	-------------	-------------
Stationary cubing from field bale.........	In container	20.80 to 39.50	23.57 to 30.50	44.37 to 70.00
	Bulk	23.80 to 42.50	27.56 to 34.11	51.36 to 76.61 d/
Stationary cubing from chopped straw......	In container	20.80 to 40.50	23.57 to 30.50	44.37 to 71.00
	Bulk	23.80 to 43.50 d/	27.56 to 34.11	51.36 to 77.61 d/
Field cubed........	In container	13.70 to 29.00	23.57 to 30.50	37.27 to 59.50
	Bulk	16.70 to 32.00	27.56 to 34.11	44.26 to 66.11 d/
Pellets...........	In container	23.70 to 37.00	22.80 to 23.68	46.50 to 60.68
	Bulk	26.70 to 40.00	14.56 to 15.66	41.26 to 55.66 d/

a/ Shipping costs to Japan are expected to be quite variable and used as a bargaining device. Special circumstances of product type, form of shipment, opportunities for two-way haul, seasonal supply pressure on containers and vessels, international balance of payments, and currency valuation relative to the dollar will all be contributing factors.

b/ The ocean freight rate for baled alfalfa hay as agreed upon by the Pacific Westbound Shippers Conference is $30.62/ton regardless of the form that it is shipped in. However, it is extremely doubtful that any baled grass residue will be shipped in containers unless the rate is changed since a container holds only 4 tons of baled straw. At the $30.62/ton rate, the container rate becomes $122.48, a price considerably below steamship quoted rates of $220 per container.

c/ Lack of technical data prevented calculation of break bulk costs for shipping super high density bales in this study.

d/ Facilities do not exist in Portland to accommodate cubes or pellets shipped break bulk. The nearest port with these facilities is Astoria. The trucking rate from Portland to Astoria is estimated at $3 per ton. This amount is added to the costs shown on Table 4 and so reflect total cost to dockside Astoria.

would eliminate the need for trucking to Astoria, reduce on-dock handling costs, and decrease ocean freight slightly since the time required for a ship to be docked for loading would decrease. It has been estimated that the loading rate for pellets could increase from the present 400 to 500 tons per hour to about 750 tons per hour and from 65 tons per hour to 400 to 500 tons per hour for cubes with improved handling facilities. If these improvements in bulk handling were achieved, an estimated reduction in handling costs from $4.50 to $5 per ton to $2.50 per ton for cubes and from $2.50 to $2 per ton on pellets could be realized [1].

Market conditions of supply and demand for commodities shipped in international trade may have a strong effect on quoted container prices. At present, discounts are made on containers shipping grass residue to Japan to avoid dead-heading (empty return) of containers. If large quantities of grass residue ultimately were shipped to Japan, then demand could exceed container supplies at current prices, forcing container prices to increase.

Another element of importance is whether the Japanese desire grass residue as a roughage or as a forage which, in turn, affects the type of densification desired. Pelleted straw is finely chopped, reducing its value as a fiber source in livestock feeding. If fiber is desired, then cubed straw or high density baled straw may prove more acceptable, even though it is somewhat more costly than pellets. This suggests that the nature and extent of Japanese demand for residue becomes a key element in terms of ultimate economic feasibility of shipping grass residue into the Japanese livestock feeding market. Modification of ocean freight rates is also a distinct possibility since many of the ocean vessels are Japanese owned. The extent to which grass residue is viewed as a unique fiber or forage source, and the availability and price of alternative fiber and forage sources become important variables in determining the extent and direction of changes in ocean freight rates.

Summary

The Japanese dairy industry, through Zenrakuren as its leading dairy cooperative, has expressed interest in obtaining densified grass seed residue as a possible source of fiber for use in dairy rations. High proportion of carbohydrate and protein feeds in concentrated forms, scarcity of rice straw, and lack of local roughage supplies have resulted in low milk production and digestive problems with existing dairy rations in Japan. Lack of fiber for rumen stimulation has been identified as the major feeding problem [12].

Efforts of the Oregon Seed Council, several private firms, and Oregon State University permitted shipment of 1000 tons of grass residue in cubed, pelleted, and high density bale forms for feeding trials by Zenrakuren in the fall of 1972. It is hoped that these preliminary efforts will expand into a mutually satisfactory commercial arrangement between Japanese dairymen and Willamette Valley grass seed producers -- for the Japanese to remedy a fiber deficiency in dairy rations and for grass seed producers in utilization of a residue which, after 1975, by law, cannot be disposed of by open field burning.

Commercial utilization of residues in any market involves both technical and economic complexities of considerable magnitude. The physical characteristics of grass seed residue determine the types of markets for which it is technically suitable and the form of densification which is most desired. These characteristics and prices of alternative sources of raw material determine the capability of grass seed residue to compete in these markets. While it is known that the Japanese are exploring alternative fiber sources such as mill feed and sugar cane pulp from Canada, Argentina, and Middle Eastern countries, it is unknown what price will be necessary for various forms of densified grass seed residue to compete with these fiber sources. One aspect of this issue requires knowledge of densification and shipment costs for grass residue delivered to Japan in various forms from grass seed fields in the Willamette Valley. This study focuses upon identification and estimation of these costs.

Standard bales, high density bales, super high density bales, cubes, and pellets were selected as alternative forms of densification. Containerization and bulk handling methods were analyzed as alternative overseas hauling choices.

A summary comparison of costs required to move grass seed residue in selected densified forms from the field to dockside Portland is shown in Table 6.

TABLE 6. Summary of Cost Per Ton (2000 lbs.) From Field to Dockside Portland For Grass Seed Residue in Selected Densified Forms, Exclusive of Any Market Value for Residue to Grass Seed Growers

Form of densification	Total cost per ton for densification & delivery to Portland
Baled straw (regular & high density)	$13.70 to $21.00/ton
Field cubed	13.70 to 29.00/ton
Super high density bale	18.70 to 33.00/ton
Stationary cubed from field bales	20.80 to 39.50/ton
Stationary cubed from chopped straw	20.80 to 40.50/ton
Pellets	23.70 to 37.00/ton

If market conditions in Japan for alternative fiber sources permit purchase of densified grass seed residue within a range of $20 to $40 per ton F.O.B. Portland, it is likely that considerable residue will be shipped from Oregon to Japanese markets. The extent to which a particular price within the range quoted will ultimately be established is a function of the relative bargaining position of prospective buyers and prospective sellers.

On the buyer or demand side, any F.O.B. Portland price must be evaluated in conjunction with overseas shipment costs and feeding capabilities of grass residue in alternative densified forms. A summary of total costs F.O.B. dockside Japan is shown in Table 7. These costs are obtained by adding ocean freight and other ocean haul charges to the costs shown in Table 6. Again, value of residue in the field is excluded since market conditions will determine whether a positive field price can be obtained.

TABLE 7. Summary of Total Cost Per Ton (2000 lbs.) in Shipping Grass Seed Residue From the Willamette Valley to Dockside Japan in Selected Densified Forms

Densification form	Overseas shipment choice	Cost range from field to dockside Japan
Super high density bale...............	container	\$37 - \$56
Field cubing..........................	container	\$37 - \$60
Pellets...............................	bulk	\$41 - \$56
Field cubing..........................	bulk	\$44 - \$66
Stationary cubing from bales..........	container	\$44 - \$70
Stationary cubing from chop...........	container	\$44 - \$71
Pellets...............................	container	\$46 - \$61
Stationary cubing from bales..........	bulk	\$51 - \$77
Stationary cubing from chop...........	bulk	\$51 - \$78
Standard bale.........................	bulk	\$53 - \$60

The fairly wide range in costs shown in Table 7 reflects differences in custom rates, volume of output, and handling requirements. Field and stationary cubing, the super high density bale, and pellets appear quite comparable in total costs when the least cost overseas shipment choice is selected. However, the cost range is large enough with any choice to suggest that, with exception of standard bales, each of the densification choices could become cost competitive. Technical consideration in Japan might then become the crucial factor as to which forms are most acceptable. At present, it appears that cubes may have a competitive edge in terms of feeding characteristics for use in dairy rations in Japan.

If a large and stable market for grass residue were to emerge in Japan, some of the costs expressed here might be reduced, especially for ocean haul charges. On the other hand, since no cost component for risk was included in the study, some costs on the supply side by grass seed producers and/or residue processors might increase. An incentive for risk may need to be included in the cost structure to provide an adequate economic base for committing resources in shipping residue to the Far East.

Product quality is also of vital importance in establishing new markets, particularly where competition is keen in use of alternative raw material sources. Some of the residue shipped to Japan in 1972 contained surface mold on delivery. Greater care must be exercised in the future to incorporate drying and cooling processes for densified residues to avoid these types of problems. Undoubtedly other technical and economic issues will need to be overcome as well. In the quest for establishment of a market, stress upon immediate gains at the exclusion of longer-run potentials should not be condoned.

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