having reached an irreversible stage of germination in the fruit.

Sealing fruit in polyethylene shrink film does not appear to have any significant effect on germination. The reduction in percentage germination in the 1983 study may have been due to an additive effect of wax and polyethylene film on gas exchange. The combination of the two can create anaerobic conditions causing the fruit to produce ethanol especially at high storage temperatures (4). Whether high ethanol inhibits citrus seed germination is not known but high CO_2 apparently does inhibit germination (5). High seed numbers in 'Duncan' grapefruit may have contributed to a potentially high CO_2 level in the fruit sealed in polyethylene shrink film. In this study, neither internal quality of the fruit nor internal CO_2 concentration during storage was evaluated.

Results of this study clearly show the tendency of seeds to germinate in the fruit as harvest is extended during the spring. Furthermore, the tendency for seeds to germinate within the fruit varies with grove location and from season to season. From a fruit quality standpoint, grapefruit intended from storage and delayed marketing should be harvested prior to the time when seeds start to germinate and stored at temperatures which inhibit germination.

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ECONOMICS OF WEIGHT BAGGING MACHINES FOR FLORIDA CITRUS PACKINGHOUSES[1]

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Abstract. **Weight bagging machines have been introduced to Florida's fresh citrus packing industry. With the high investment cost of these machines, the question arises as to what will be the payback period for the investment cost. To answer this question, labor and material costs and the additional fruit packed from weight savings are compared to the conventional packer's aid method of bagging fresh citrus fruit. Four seasonal volume packs of bag master cartons—25,000, 50,000, 100,000, and 200,000—are used in the analysis. Assuming a 100% machine efficiency for the mesh-net bags, the break-even periods are 5.64, 2.82, 1.41, and 0.70 yr, respectively, whereas mesh-net bag and poly bag packed in equal volumes the break-even periods are 10,59, 5.29, 2.65, and 1.32 yr. When the savings from increased fruit bagged and packed are added, the break-even periods assuming a 100% machine efficiency are 3.03, 1.51, 0.76, and 0.38 yr for the mest-net bag and 4.79, 2.40, 1.20, and 0.60 yr for the mesh-net bag and poly bag packed in equal volumes.**

Florida's fresh citrus packing industry is labor intensive. From discussions with citrus packers, the authors have found that the use of packer's aids reduced labor requirements from an average of 5 workers to 4 workers per equal volume of citrus fruit packed. Labor costs have increased due to higher minimum wage rates, workmen's compensation insurance, incentive piece rates, and other fringe benefits. Thus labor saving equipment is becoming an increasingly important consideration.

With respect to bagging fresh citrus fruit, an additional cost has been incurred by the packer due to an excess fruit weight being packed per bag. For this paper, the standard 5 lb. size fruit bag was used. A 1979-80 season survey indicated that the average weight for bagged oranges, all sizes, was 5 lb. and 11 oz (Florida Citrus Mutual, 1980, unpublished). According to a 1978 study on automatic weighing equipment (1), the preferred weight per bag for fresh citrus fruit that would allow shrinkage before shipping would be 5 lb. 4 oz.

Weight bagging machines are one possible alternative to reducing labor and material costs and providing a more accurate weight count for bagged fruit. This paper will explore the payback period of a typical machine.

Analysis

During the spring of 1984, the authors visited 2 fresh citrus packinghouses to observe the only weight bagging machine being used by Florida citrus packers. Time requirements for weighing, bagging, packing a pallet equivalent of bagmaster cartons, and labor requirements for the weight bagging machine were recorded. Likewise, the authors, through discussions with commercial citrus packers, obtained information on the labor and cost requirements using the conventional packer's aid. Bag material costs and equipment prices were obtained from the manufacture of the weight bagging machines which we observed. [*Note*: During the 1983-84 fruit season, one manufacturer (Tomac Corporation, Woburn, Massachusetts) had machines in operation for Florida citrus.]

Data and Results

Table 1 presents the list price for the weight bagging machine which the authors observed. The cost for a machine with mesh-net bags capability is $69,000. An additional cost of $23,000 would allow poly bags to be

[1]Florida Agricultural Experiment Stations Journal Series No. 5971.

utilized by the same machine. The estimated useful life is 10 yr with the ACRS depreciation classification (6) being 5 yr. The full investment tax credit of 10% would be available on the machine purchase cost.

Table 1. Data for a single weight bagging machine.

List price with:	
Mesh-net bag	$69,000
Both mesh-net and poly bags	$92,000
Estimated useful life (yr)	10
ACRS depreciation classification (yr)	5
Amount of investment tax credit:	
Mesh-net bag	$ 6,900
Both mesh-net and poly bags	$ 9,200

Table 2 summarizes the labor requirements and costs associated with using packer's aid equipment or a weight bagging machine. Four employees are required for packing an equivalent volume of citrus fruit per day that 1 employee could pack using a weight bagging machine. An average of 6.5 hr (81%) of actual work time is performed during an 8.0 hr work day. Lunch, breaks, and changing of citrus varieties on the packingline account for the 1.5 hr of lost time. Earlier studies reported similar labor efficiency when using continuous bag filling equipment (2).

Table 2. Labor requirements and costs for packing bagged citrus fruit.

	With packer's aid	Weight bagging machine
Number of employees	4	1
Actual work time per 8 hr day	6.5	6.5
Desired pack wt	5 lb. 4 oz	5 lb. 4 oz
Total bags packed per min/worker	4.8	19.2
Total bags packed per 8 hr day	7488	7488
Total bagmasters packed per day	936	936
Labor costs:		
Hourly cost of labor (includes fringes, piece rate, etc.)	$.600	$6.00
Total labor cost per 8 hr day	$192.00	$48.00
Labor cost: cents per bag	2.56	0.64
Labor savings per bag using weight bagging machine: cents per bag	1.92	—

	Mesh-net bag	Poly bag
	cents per bag	
Cost of materials (bag with clamp):		
Hand packed	5.60	2.70
Weight bagging machine	1.40	1.85
Cost savings per bag	4.20	0.65
Total labor and material cost savings per bag using weight bagging machine	6.12	2.57

The average number of 5 lb. bags packed per minute is 4.8 per employee using a packer's aid whereas 19.2 bags can be packed per employee with a weight bagging machine. Total bags packed per day is estimated to be 7,488 or 936 bagmaster equivalents—approximately 1 semi-trailer load of citrus fruit.

Hourly labor costs for each employee is estimated to be $6.00. This includes the guaranteed minimum wage rate, cost of fringe benefits, workmen's compensation insurance, and the added incentive payment for piece rate work. Total daily labor cost is estimated to be $192.00 for the 4 packer's aid employees and $48.00 for the 1 weight bagging machine employee. On a per bag basis, the costs are 2.56¢ and 0.64¢, respectively, with a resulting labor savings using the weight bagging machine estimated to be 1.92¢ per bag. Bowman (2) reported labor costs for the continuous bag filling machine to be 0.95¢ per bag (1984 equivalent cost).

The per bag cost for material—bag with clamp—for the 5 lb. mesh-net bag is 5.60¢ for the hand pack and 1.40¢ for the machine pack or a 4.20¢ savings. Likewise the poly bag cost is 2.70¢ and 1.85¢ per bag for each packing method, respectively, or an 0.65¢ savings. Total labor and material cost savings per bag is 6.12¢ and 2.57¢ for the mesh-net and poly bags, respectively.

In addition to the cost savings with labor and material, a potential savings via increased packable fruit exist if a weight bagging machine is used. Machine weighing and bagging of citrus fruit enables a more accurate weight to be maintained for each bag of fruit packed. Therefore, the weight savings obtained over the conventional manual packing should result in an increased number of bags due to less fruit being packed per bag.

Table 3 presents overweight savings and potential increase in citrus bags. Average manual packing weight per bag was determined in a survey conducted during the 1979-80 season (Florida Citrus Mutual, 1980, unpublished). For oranges, the average per 5 lb. bag was 5 lb. and 11 oz. The weight range being used in the weight bagging machine the authors observed was a minimum of 5 lb. and 1.75 oz and a maximum of 5 lb. and 3.75 oz. For the analysis, a minimum of 5 lb. 4 oz and a maximum of 5 lb. and 5 oz was assumed.

Table 3. Overweight savings per bag.

	Lb.	Oz.
Average manual pack wt[z]	5	11.0
Desired pack wt	5	4.0
Excess pack wt	0	7.0
Average weight bagging machine pack wt[y]	5	4.5
Desired pack wt	5	4.0
Excess pack wt	0	0.5
Overweight saving	0	6.5

Value of overweight savings:	Mesh-net bag	Poly bag
Value of additional packed fruit[x]:		
per carton	$ 5.46	$ 5.40
per lb.	13.00¢	12.85¢
Value per additional bag packed[w]	5.28¢	5.22¢

[z]1979-80 season average for orange pack sizes of 64, 80, 100, and 125 fruit per carton. Unpublished report of Florida Citrus Mutual.
[y]Assumed machine set for weight bagging range of 5 lb. 4 oz minimum to 5 lb. 5 oz maximum.
[x]Assumes that the costs of purchase, harvest, and grading of the fruit saved has already been incurred and the value at this point is the sales value less additional costs of packing, selling, and administrative (3, 5).
[w]Calculated by: additional value per lb. (mesh-net or poly bag) x 40.6% lb. (6.5 oz ÷ 16 oz) per bag savings; e.g. 13.00¢ x 40.6% = 5.28¢ per mesh-net bag.

Total weight savings using the weight bagging machine is 6.5 oz per bag or the equivalent of 72 additional cartons per day. When using continuous bag filling machines, Bowman (2) reported that randomly checking and weighing filled bags would enable an additional 15 mesh-net bag and 19 poly bag cartons to be packed per day. Total value per bag packed by the weight bagging machine was estimated to be 5.28¢ for the mesh-net bag and 5.22¢ per bag for the poly bag.

Payback Period Analysis

Table 4 presents the summary for the mesh-net bag weight bagging machine. Four seasonal volumes of cartons

packed—25,000, 50,000, 100,000, and 200,000—are used in the analyses. The 200,000 carton volume would most represent a packer working two 8 hr shifts per day. The payback period in yr for the machine assuming a 100% and 50% machine efficiency is shown. With respect to cost savings for labor and material, the payback periods at 100% machine efficiency are 5.6, 2.8, 1.4, and 0.7 yr for the four seasonal pack volumes, respectively. If the machine operates at 50% efficiency the payback period would double. When the potential increased fruit packed is added to the cost savings, the payback periods at 100% efficiency are 3.0, 1.5, 0.8, and 0.4 yr, respectively, for the 4 seasonal pack volumes. The payback periods double when the machine efficiency decreases to 50%.

Table 4. Payback analysis for the purchase of a weight bagging machine, mesh-net bags.

	Annual bagmaster cartons packed			
	25,000	50,000	100,000	200,000
Cost savings on labor and material	$12,240	$24,480	$48,960	$97,920
Payback period in yr @ 100% efficiency	5.6	2.8	1.4	0.7
Payback period in yr @ 50% efficiency	11.3	5.6	2.8	1.4
Add savings:				
Increased fruit packed from weight savings	$10,560	$21,120	$42,240	$84,480
Total savings	$22,800	$45,600	$91,200	$182,400
Payback period in yr @ 100% efficiency	3.0	1.5	0.8	0.4
Payback period in yr @ 50% efficiency	6.1	3.0	1.5	0.8

Table 5 presents the payback analysis for using a weight bagging machine with mesh-net and poly bag capabilities. The analysis assumes the same seasonal volume packed as above and that one half of the fruit is packed in each type bag. At 100% efficiency, the payback periods for labor and material cost savings are 10.6, 5.3, 2.7, and 1.3 yr for the respective seasonal volume pack. Adding the potential fruit packed to the labor and material cost savings, the payback periods are reduced to 4.8, 2.4, 1.2, and 0.6 yr, respectively. Again with 50% machine efficiency, the payback periods double.

Limitations to Payback Period Analysis

Payback period analysis assumes that limited funds are available and that no capital outlay can be made unless the money can be recovered within a short time period (4). Deciding to invest based slolely on the payback period of a capital outlay, an investor may overlook the overall rate of return on investment of the alternative investments.

The use of the payback period in this paper was to demonstrate the time in which the weight bagging machine investment could be recovered with respect to different volume packs and machine efficiencies. A thorough investment analysis as to how the weight bagging machine will benefit the packers business operation should be conducted by the packer before a final decision is made.

Table 5. Payback analysis for the purchase of a weight bagging machine, mesh-net and poly bags.

	Annual bagmaster cartons packed[z]			
	25,000	50,000	100,000	200,000
Cost savings on labor and materials	$8,690	$17,380	$34,760	$69,520
Payback period in yr @ 100% efficiency	10.6	5.3	2.7	1.3
Payback period in yr @ 50% efficiency	21.2	10.6	5.3	2.7
Add savings:				
Increased fruit packed from weight savings	$10,500	$21,000	$42,000	$84,000
Total savings	$19,190	$38,380	$76,760	$153,520
Payback period in yr @ 100% efficiency	4.8	2.4	1.2	0.6
Payback period in yr @ 50% efficiency	9.6	4.8	2.4	1.2

[z]Assumes one half bagmaster cartons packed with mesh-net bags and one half bagmaster cartons packed with poly bags.

Conclusion

Weight bagging machines have the potential of reducing the costs of labor and materials used in packing fresh citrus fruit. Of the 2 types of bags used, mesh-net and poly, the greater potential savings is with mesh-net bags. Also, the weight savings from using a weight bagging machine would allow for additional bags being packed.

Before a packer considers purchasing a weight bagging machine, comparisons of the different machines available should be made. Due to the differences in cost savings of the 2 types of bags, an analysis of the number of each bag type is needed to determine the actual payback period. Also, annual depreciation and investment tax credit deductions should be incorporated into an annual cash flow budget analysis. For example, at the 50% tax rate, the first yr depreciation and investment credit benefits would be $11,816 for the mesh-net weight bagging machine and $15,755 for the combined mesh-net and poly bag machine.

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