Staff Paper

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Profitability Analysis of Soybean Aphid Control Treatments in Three North-central States

1. Background

Soybean aphid (SBA) is a new invasive pest first detected in Wisconsin in 2000. It rapidly spread to over 20 states across the north-central United States in the following years (Venette and Ragsdale, 2004). By sucking the plant's sap, heavy soybean aphid infestation can reduce soybean plant vigor, reducing grain yield and quality. During 2003, over 42 million acres of soybean in the north-central United States were infested (Landis, et al., 2003). Estimates of state-level average yield loss range from 9 to 13 bushels (bu) per acre (Hunt, 2004, Myers and Wedberg, 2002, Rice, et al., 2004). Even at the lower end of this spectrum, total yield loss without treatment could exceed 350 million bushels. Translated into money terms at a soybean price of $7/bu, the economic loss could be worth over $2.4 billion. This estimate provides an upper bound on the potential value that might be saved by effective aphid control. In 2004, Michigan producers spent $8-12/acre for insecticide application. This represents roughly a 12 percent increase in general operating costs and a 30 percent increase in the chemical cost category over levels for the national middle 50% in 1997 (Forman and Livezey, 2002). At a time when South American soybean producers have been rapidly expanding their output (Ash, Livezey and Dohlman, 2006), the increased costs for U.S. farmers to manage invasive soybean aphid and soybean rust threaten the international competitiveness of the U.S. soybean industry.

In response to the severe economic loss caused by soybean aphid in 2003, farmers treated over 7 million infested acres with insecticides (Landis, et al., 2003). The following year, many sprayed prophylactically, applying insecticides as seed treatments or tank-mixed with herbicides and applied early in the season.

Although convenient, prophylactic control of soybean aphid is not necessarily efficacious or profitable. First, insecticide applied too early may not endure to control late-arriving aphids in late July (Anonymous, 2005). Second, if the aphid population is low, it may not cause significant yield loss, in which case the yield protection benefit from a prophylactic treatment may fail to cover its cost. Preliminary research from Minnesota suggests an action threshold of 250 aphids per plant (Ragsdale et al., 2006), suggesting that spraying insecticides when infestation rates are lower may not be cost effective. Apart from the effectiveness and profitability of aphid control with insecticides, Warrior, the dominant current insecticide, poses moderate toxicity threats to human heath and to environmental contamination (Appendix 1).

In order to evaluate management alternatives for the soybean aphid, a multilocational field experiment was established in 2005 to compare prophylactic control with an action threshold of 250 aphids/plant (the “best management practice” or BMP treatment) and an untreated control. The experiments were set up at two sites each in the states of Michigan, Iowa and Minnesota under the project “Soybean Aphid in the North Central US: Implementing IPM at the Landscape Scale” funded by the U.S. Department of Agriculture’s Risk Avoidance and Mitigation Program (RAMP).

The overall research objective is to enhance the knowledge available to soybean farmers for improved decision-making on soybean aphid management. In order to assess the potential for adoption of alternative soybean aphid pest controls, this paper reports yield and profitability results for the 2005 season.

2. Objective

This paper aims to compare the profitability and riskiness of three soybean aphid control treatments: 1) prophylactic control (with Warrior insecticide), 2) “best management practice” (BMP) where SBA control is based on a population density threshold (apply Warrior insecticide if SBA density exceeds 250 per plant), and 3) no control.

3. Methods

3.1 Experimental Design

A RAMP treatment protocol was set up across three states, Michigan, Iowa and Minnesota. In each state, two sites were selected that represent different soybean production areas. At each site, three treatments were established, representing no control, prophylactic treatment and a best management practice based on aphid population scouting. The prophylactic treatment (PRO) uses an insecticide and fungicide tank mix at the Late R2 soybean growth stage, regardless of the aphid population. Best management practice (BMP) consists of weekly scouting, followed by treatment with 3.2 oz/acre of Warrior if the threshold of 250 aphids per plant is exceeded. During 2005, there were two exceptions to this protocol. The first exception occurred at Rosemount, MN, where 2 oz/acre Warrior plus 6.2 oz/acre Headline was used. The second was at Lamberton, MN, where 2 oz/acre Warrior and 12 oz/acre Quilt were used for the prophylactic treatment (see Table 1). Also, at the Saginaw Valley Dry Bean and Sugar Beet Farm in Saginaw, MI, two other treatments were applied in addition to the three standard treatments. They were Cruiser seed treatment at planting and Cruiser seed treatment combined with Warrior 3.2oz/acre at the 250 aphid threshold (Cruiser + BMP).

A grower advisory panel was established in each state to advise researchers on variety selection, planting density and other cultural practices. For consistency across all trials soybeans were planted minimum-till into corn on 30-inch rows at a density of 170,000-200,000 plants per acre. Locally adapted varieties and maturity groups were used at each location as selected by the grower panels. Glyphosate tolerant soybean varieties were planted, as these represent the grower standard throughout the region. Each trial contains the same three treatments replicated a minimum of four times in approximately 1 acre plots. The yield and costs that vary across the treatments were recorded.

Table 1: RAMP Soybean Aphid Treatments and Sites, 2005.

Treatments	Insecticide	Fungicide	Application Sites
Untreated	N.A	N.A	All the sites
Prophylactic	Warrior 3.2oz/acre	Headline 6.2oz/acre	Bean & Beet Farm (B&B Farm) (MI); Kellogg Biological Station (KBS) (MI) Johnson Farm; McN Farm (IA)
	Warrior 2oz/acre	Headline 6.2oz/acre	Rosemount (MN)
	Warrior 2oz/acre	Quilt 12oz/acre	Lamberton (MN)
BMP	Warrior 3.2oz/acre	N.A	B&B Farm (MI); KBS (MI); Johnson Farm (IA); McN Farm (IA); Lamberton (MN)
	Warrior 2oz/acre	N.A	Rosemount (MN)
Cruiser	Cruiser seed trt.	N.A	Bean & Beet Farm (MI)
Cruiser+BMP	Cruiser seed trt. Warrior 3.2oz/acre	Headline 6.2oz/acre	Bean & Beet Farm (MI)

3.2 Profitability Analysis

The profitability across treatments is given by:

$$\pi_i = py(t_i \mid \theta) - c(t_i \mid \lambda) - c_0$$

π: profit; p: price;

$y(t_i|\theta)$: yield as a function of treatment;

θ: extraneous factors that contribute to the yield, such as fertilizer;

t_i:treatment; $c(t_i|\lambda)$: costs that vary across the treatments;

λ: input prices; c_0: costs that are the same across the treatments.

To compare the economic performance of the prophylactic and BMP treatments, we need first to calculate the gross revenue and the costs that vary across the treatments. Because those costs unrelated to SBA are constant across treatments, they are excluded from the analysis. The analysis focuses on the gross margin, which is gross margin minus costs that vary across the treatments..

$$GM_i = py(t_i \mid \theta) - c(t_i \mid \lambda)$$

The variation of the gross margin among the treatments can be shown from the experimental field results. However, treatment effect is not the only source of this variation. We need a way to separate the treatment effect from the other sources and determine how it affects the gross margin variation. Analysis of variance (ANOVA) is a classic method to analyze the variation of the dependent variables and the effects of the independent variables on the variation of the dependent variables. Following Swinton et al. (2002), we used ANOVA to analyze the variation of the gross margin and to see if mean gross margins differ significantly among the treatments.

3.3 Data

Price: Annual U.S. soybean prices vary over time. We collected U.S. season average farm-level prices released by the U.S. Department of Agriculture from 1963 to 2004 and adjusted them for inflation using the Producer Price Index (PPI, 2004 base year) (data in Appendix 2). To predict a typical long term price, we regressed the inflation-adjusted price on the year in linear, logarithmic and quadratic form regression models. The following logarithmic form regression model captured the data characteristics best and was used to obtain a typical long term price.

$$LogP = 2.22 - 0.08LogY$$

t-value (25.8) (-2.6)

P : U.S.season average farm price for soybean

Y: Year

As the Year variable was calculated from 1963=1, to predict the 2005 real price (in 2004 dollars), we plugged in Year=43 to obtain $p = \exp(2.22 - 0.08Log43)$, which is $6.91 per bushel.

Yield: The yields recorded from the six experimental sites in three states are reported in Table 2.

Table 2 Mean Soybean Yields by RAMP Treatment and Site in 2005

Treatment	RAMP Sites					
	B&B Farm (MI) (bu/acre)	KBS (MI) (bu/acre)	Johnson Farm (IA) (bu/acre)	McN Farm (IA) (bu/acre)	Rosemount (MN) (bu/acre)	Lamberton (MN) (bu/acre)
Untreated	17 d	35 a	64 a	65 b	50 a	42 b
Prophylactic	38 b	33 a	65 a	68 a	53 a	56 a
BMP	37 b	36 a	64 a	67 a	49 a	56 a
Cruiser/Treated	50 a					
Cruiser/Untreated	30 c					

NB: Within columns, means followed by the same letter do not differ by Dunnett's multiple comparison test (two-sided p=0.05).

Costs that vary: Costs that vary across treatments include the chemical input costs, scouting costs and the spraying costs. The chemical input costs for each treatment were calculated according to their prices and application rates (see Appendix 3) and are shown in Table 3. The spraying costs were based on the owned equipment custom rate in Schnitkey and Lattz (2005) (details in Appendix 4). Scouting costs of $2/acre come from Michigan crop consultant, Matt Duchrow[1], who scouted aphids for his clients twice averagely in the summer at a rough rate of $1 per visit.

[1] Personal communication, telephone conversation by Scott Swinton with Matt Duchrow of Agri-Business Consultants, Inc. , 18 Jan, 2006. During summer 2005, Matt Duchrow scouted 520 acres of soybeans for soybean aphid. At his rate of $60 per hour, the total fees for all 520 acres were $465. His conservative estimate of a per-visit rate is $1. Most of Mr. Duchrow's clients had him scout their fields 2 times.

Table 3 Costs that Vary by Treatment, RAMP Soybean Aphid protocol in Michigan, Iowa and Minnesota, 2005.

Treatment	Site	Insecticide Cost ($/ac)	Fungicide Cost ($/ac)	Cruiser Cost ($/ac)	Scouting Cost ($/ac)	Spraying Costs ($/ac)	Total costs $/acre
Untreated	All sites	0.00	0.00	0.00	0.00	0.00	0.00
Prophylactic	Bean & Beet Farm (MI) Kellogg Biological Station (KBS) (MI)	6.98	12.11	0.00	0.00	3.20	22.29
	Rosemount (MN)	4.35	12.11	0.00	0.00	3.20	19.66
	Lamberton (MN)	4.35	11.91	0.00	0.00	0.00	19.46
BMP(Threshold Reached)	Bean & Beet Farm (MI) Johnson Farm (IA); McN Farm (IA) Lamberton (MN)	6.98	0.00	0.00	2.00	3.20	12.18
	Rosemount (MN)	4.35	0.00	0.00	0.00	0.00	9.55
BMP/(Threshold Not Reached)	Kellogg Biological Station (MI)	0.00	0.00	0.00	2.00	0.00	2.00
Cruiser/Treated	Bean & Beet Farm (MI)	6.98	0.00	20.40	0.00	3.20	30.58
Cruiser/Untreated	Bean & Beet Farm (MI)	0.00	0.00	20.40	0.00	0.00	20.40

Note: See Table 1 for pesticide rates applied.

4. Results

4.1 Gross margin ANOVA

Mean gross margins in 2005 did not differ between prophylactic and best management treatments except at the McN farm in Iowa. In principle, gross margin differences in agronomic experiments with fixed product prices can result either from differences in yield or costs that vary across treatments. In most sites, the treatment ranking for gross margins across treatments is the same as for yields, which means the yield effect is dominant. McN Farm (IA) is the exception, because although the yields between the prophylactic and best management treatments did not differ significantly at the 5% level, the difference in costs that vary changed the gross margin relationship.

Table 4 Mean Gross Margin by RAMP Treatment and Site

	RAMP Sites					
Treatment	B&B Farm (MI)	KBS (MI)	Johnson Farm (IA)	McN Farm (IA)	Rosemount (MN)	Lamberton (MN)
Untreated	127 d	239 a	436 a	451 a/b	345 a	288 b
Prophylactic	238 b	207 a	425 a	448 b	357 a	376 a
Best Management	245 b	247 a	440 a	460 a	330 a	378 a
Cruiser/Treated	317 a					
Cruiser/Untreated	188 c					

Means in the same column followed by the same letter do not significantly differ (p=0.05, LSD).

4.2 Gross margin risk efficiency analysis

Farmers in some settings have been found to be reluctant to adopt integrated pest management methods because of aversion to the risk of failure adequately to control a pest infestation (Marra and Carlson, 2002). Risk efficiency analysis methods allow assessment of the relative riskiness of alternative soybean aphid control treatments. Mean-variance efficiency analysis is one specific method for identifying preferred treatments. A treatment is preferred (in the dominant set) if it has a higher mean and same or lower variance, or else if it has the same or higher mean and a lower variance compared to another treatment. For this research, standard deviation is used in lieu of variance, because it has a one-to-one rank correspondence with variance and it shares the same units of measure as the mean. Mean-standard deviation comparisons are illustrated by state for the six sites in Figures 1-3.

The efficiency analysis results show that the Untreated treatment is dominated by other treatments at all six experimental sites in 2005. A trade-off between the BMP (higher mean, higher s.d.) and Prophylactic (lower mean, but lower s.d.) was found at the two Michigan sites, as well as at the Johnson Farm in Iowa. At the McN Farm in Iowa and the Lamberton station in Minnesota, the BMP treatment dominated both the other two.

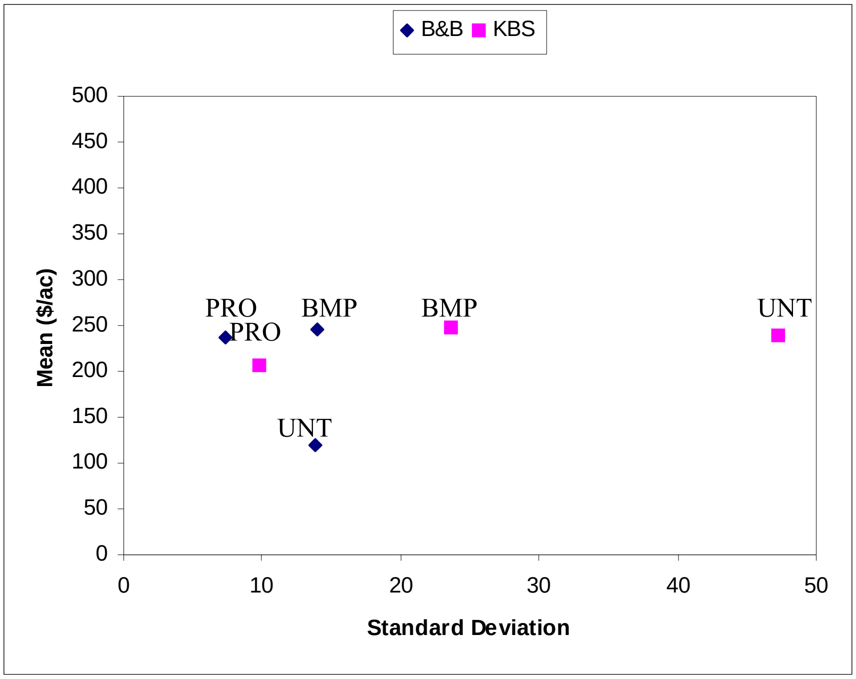

Figure 1: Gross margin mean-standard deviation efficiency comparisons for Michigan soybean aphid aphids RAMP trials, 2005

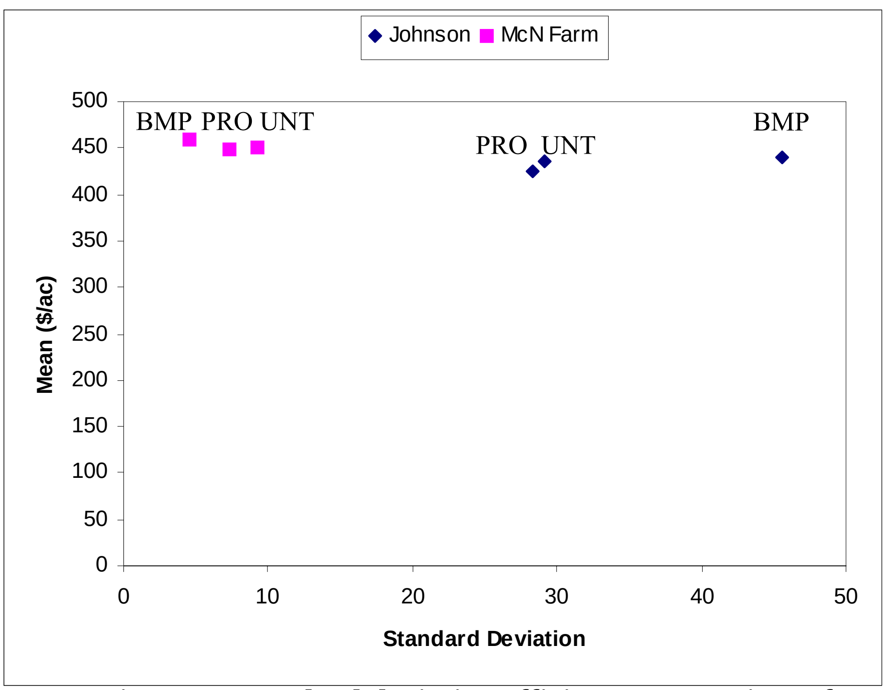

Figure 2: Gross margin mean-standard deviation efficiency comparisons for Iowa soybean aphid RAMP trials, 2005.

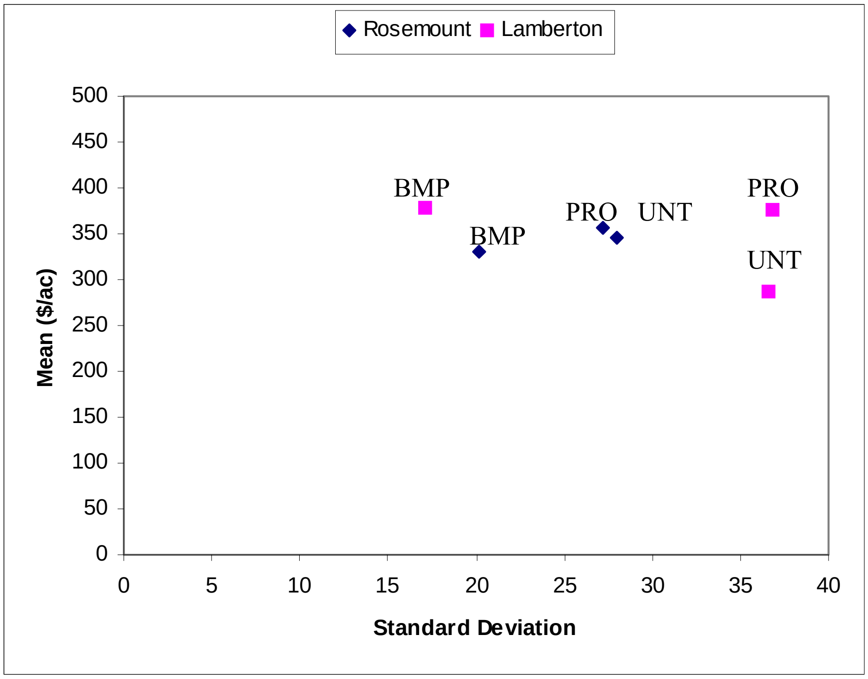

Figure 3: Gross margin mean-standard deviation efficiency comparisons for Minnesota soybean aphid RAMP trials, 2005.

Conclusion

Experimental results from 2005 on the profitability of insecticide-based soybean aphid control in Iowa, Michigan and Minnesota suggest the following:

(1) Where statistical differences existed at the 5% level, the prophylactic and best management practice (BMP) treatments generally gave higher mean gross margins (a measure of profitability) than no treatment (2 of 3 sites**).**

(2) Mean-standard deviation efficiency analysis revealed that in 3 of 6 sites, the BMP treatment gave higher mean but also a higher standard deviation than the prophylactic treatment. This suggests that more risk averse farmers may prefer the prophylactic treatment.

These results are for one season only. The experiments are continuing in 2006.

Appendix 1:

Toxicological Information for Pesticides in RAMP Soybean Aphid Trials, 2005

Pesticide trade name	Pesticide scientific common name	Acute toxicity: Oral (LD50 Rat)	Classification
INSECTICIDES			
Warrior	Lambda cyhalothrin	351mg/kg body weight	Moderately Toxic
FUNGICIDES			
Cruiser	Thiamethoxam	5,523 mg/kg body weight	Practically Non-Toxic
Headline	Pyraclostrobin	1,700 mg/kg body weight	Slightly Toxic
Quilt (Quadris + Tilt)	Azoxystrobin + propiconazole	1,750 mg/kg body weight	Slightly Toxic

Source: Material Safety Data Sheets (Syngenta Crop Protection, Inc. 2004a, 2004b, 2005; BASF Corp. 2005)

WHO 2005. The WHO recommended classification of pesticides by hazard and guidelines to classification: 2004. Geneva.

Appendix 2:

U.S. Annual Average Farm-gate Soybean Prices,

Adjusted by the Producer Price Index (PPI) for Farm Products

Year	Soybean	PPI	Adjusted	Year	Soybean	PPI	Adjusted
1963	2.51	32.14	7.81	1984	5.84	85.63	6.82
1964	2.62	31.66	8.28	1985	5.05	77.19	6.54
1965	2.54	33.04	7.69	1986	4.78	75.41	6.34
1966	2.75	35.47	7.75	1987	5.88	77.52	7.59
1967	2.49	33.52	7.43	1988	7.42	85.15	8.71
1968	2.43	34.33	7.08	1989	5.69	90.02	6.32
1969	2.35	36.53	6.43	1990	5.74	91.07	6.30
1970	2.85	37.18	7.67	1991	5.58	85.80	6.50
1971	3.03	37.83	8.01	1992	5.56	84.09	6.61
1972	4.37	41.88	10.43	1993	6.40	86.93	7.36
1973	5.68	59.01	9.63	1994	5.48	86.28	6.35
1974	6.64	62.83	10.57	1995	6.72	87.18	7.71
1975	4.92	62.50	7.87	1996	7.35	99.35	7.40
1976	6.81	63.96	10.65	1997	6.47	91.64	7.06
1977	5.88	64.45	9.12	1998	4.93	84.90	5.81
1978	6.66	71.19	9.36	1999	4.63	79.87	5.80
1979	6.28	80.85	7.77	2000	4.54	80.76	5.62
1980	7.57	83.52	9.06	2001	4.38	84.25	5.20
1981	6.07	85.39	7.11	2002	5.53	80.36	6.88
1982	5.71	81.17	7.03	2003	7.34	90.50	8.11
1983	7.83	83.12	9.42	2004	5.80	100.00	5.80

Source: USDA (via Dr. Jim Hilker, MSU Department of Agricultural Economics) and CEA, 2006.

Appendix 3:

Treatment Cost Calculations

Chemical Inputs	Price	Application Rate	Costs for per acre
Warrior	$279/gal	3.2 oz/acre	$6.98/acre
		2.0 oz/acre	$4.35/acre
Headline	$250/gal	6.2 oz/acre	$12.11/acre
Quilt	$127/gal	12 oz/acre	$11.91/acre
Cruiser	$12/50 lb bag	60 lb/acre	$20.40/acre

Appendix 4:

Cost of Spraying

Two data sources for spraying costs were available, Doane's Agricultural Report with data from University of Illinois (Schnitkey and Lattke, 2005) and Farm Machinery Economic Cost Estimates Report from University of Minnesota (Lazarus and , 2005). The spraying cost used here is $3.20/acre from Doane's Agricultural Report, which is much higher than $2.09/acre from University of Minnesota.

The higher fixed costs in the Doane's report come from assumptions of larger tractor size, shorter depreciable life time, higher interest rate and insurance charges. The overhead costs were $2.20/acre, accounting for 69% of the total costs. Overhead costs in the Minnesotas report the overhead costs were $0.71/acre, accounting for 34% of the total costs. Higher variable costs assumed in the Minnesota report came from higher assumed fuel cost of $2.20/gallon for diesel versus $1.50/gallon assumed by Doane's. However, this difference is not big enough to offset the effect of the difference of the fixed costs.

We selected the more conservative (total cost) estimate in view of rising energy prices. Hence we chose the $3.20/acre figure, despite the fact that the higher value of the Doane's figure comes from higher assumed fixed costs, rather than variable costs.

Table A4: Parameters compared for spraying costs from two reports

General Parameters	Doane's Agricultural Report[a]	Minnesota Farm Machinery Economic Cost Estimates Report[b]
Tractor Size (HP)	60	90
Year of Life	12	10
Interest Rate	6% (% of average investment)	7% (% of remaining value)
Insurance Rate	0.85%, (% of average investment)	1% (% of remaining value)
Fuel price, $/gallon	2.2	1.5
Lubrication cost, % of fuel	0.15	0.1
Labor Rate $/hr.	13	13.5

Sources: [a]Schnitkey and Lattz, 2005

[b]Lazarus and Selley, 2005.

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