FUEL CONSUMPTION IN SPINDLE PICKER COTTON HARVESTING SYSTEMS

Michael H. Willcutt
MSUES Ag. & Bio. Engineering
Mississippi State, MS
Edward M. Barnes
Cotton Incorporated
Cary, NC

Abstract

Fuel consumption of cotton harvesting machinery systems was monitored over a minimum of five days of harvesting for two systems in 2006, and an additional five systems in 2007, and compared to historic data and crop budgets. Fuel consumption per harvested acre of cotton increased from 1.75 gallons/ac (gasoline) in 1942, to 2.4 gallons/ac (diesel) for two row harvesters in the mid 1960's to 1.83gallons/ac (diesel) for the current six row basket pickers. Per bale fuel consumption has decreased from 4.08 gallons of gasoline per bale in 1942 to 1.20 gallons/bale with current six row pickers due to increased yields. Handling systems have helped to reduce non-productive time at a small additional fuel consumption of 0.66 gallons/ac or 0.30 gallons/bale.

Introduction

Since the introduction of the cotton picker in 1942, and marketing of the spindle type cotton picker in 1943 and 1944, fuel consumption for the harvest operations has been a concern in determining accurate estimates of harvesting costs. In 1942 through 1944, in the Mississippi Delta, International Harvester Engineers reported fuel usage of 2.33 hours/bale with a consumption of 1.75 gallons/ac yielding a consumption of 4.08 gallons/bale at $0.15 per gallon, or $0.61 for gasoline to harvest the first spindle picked cotton (Hopson, McCormick-Deering). During the 1960's two-row spindle cotton pickers were reported to consume 2.44 gallons of diesel/ac for first picking and 1.97 gallons/ac for second picking (Williford, 1981). These figures were increased to 3.0 and 2.4 gallons/ac for first and second picking respectively, in a later report (Williford, 1982). A report covering a two year field scale study (Dumas, W. T. & E. Renoll) showed fuel consumption for a two row picker to be 2.05 gallons/ac for first pick and further reported that primary tillage and harvesting amounted to 8.24 gallons/ac or 75% of the fuel usage to produce a crop of cotton. Mathews, et al. reported fuel consumption for a gasoline powered spindle picker on clay soils as 3.61 gallons/ac and a diesel powered stripper as 0.54 to 0.98 gallons/ac for finger and brush type strippers respectively.

Fuel consumption records are not available since the early 1980's; however, recent records and budgets for cotton production have relied on estimates derived from formulas based on a percentage loading and engine horsepower available. Mississippi State University Extension Service Planning Budgets for Cotton (2007) shows fuel consumption for a six-row spindle harvester estimated at 16.98 gallons/hr and a performance rate of 0.145 hr/ac, or an effective fuel consumption of 2.46 gallons/ac. Nelson, et al. reported that West Texas farmers estimated fuel consumption for pickers and strippers operated on an average of about 50 gallons/day over a 10-hour day.

The seemingly casual assumptions reported above and the increases in fuel prices experienced in the past four years could introduce substantial errors in cost-of-production estimates. A study was initiated in 2006 and expanded in 2007, to establish a more accurate fuel usage prediction in harvesting operations for current six-row basket pickers with the supporting handling equipment with plans to include pickers with onboard packaging systems at a later date.

Methods

Daily fuel consumption, hours of operation and acres harvested were recorded for two farms in 2006 and six farms in 2007. Fuel dispensed into a machine was measured with inline digital fuel flow meters calibrated against a fuel cylinder. Consumption per hour and acre was determined by filling the machine each morning and recording the amount of fuel consumed on the previous day of operation. Each machinery system was monitored for five or more consecutive days of harvesting.

A computer and operator in the cab of the pickers were used to record the instance and location of each change in operation status. Time-in-motion data was taken for a complete day of operation on several operations in 2006, to determine the efficiency of conventional harvest systems. One module builder, one boll buggy, two tractors and farm assignment of labor was designated to support each picker being monitored. The boll buggy met the pickers on the row allowing the picker to unload with minimum lost time with one exception where the picker unloaded on the turn row even if it was necessary to stop harvesting and drive to the end of the row with a loaded basket. In 2007, a GPS system was added to the data logging operation to provide row length, travel speeds and distances, location of full baskets, etc. Support equipment was found to be adequate and did not delay the harvester in 2006, and was therefore not monitored other than any harvester time spent waiting for a boll buggy to dump in 2007.

Results and Discussion

An example of fuel consumption records for one farm's harvesting system over 16 days is provided in Table 1. Fuel consumption is summarized for the eight six-row conventional basket pickers (Table 2) and averaged 10.53 gallons per engine operating hour for the harvesters. Fuel consumption of tractors powering module builders and boll buggies was monitored on the same operations and averaged 1.92 gallons/hr for the module builder and 2.12 gallons/hr for the boll buggy operation. Based on picker hours of operation, this translates to 0.34 gallons/ac and 0.155 gallons/bale for the module builder and 0.38 gallons/ac and 0.174 gallons/bale for the boll buggy operations. Total handling system fuel usage was 0.72 gallons/ac and 0.33 gallons/bale. Travel distance, pickers supported, soil type and moisture content and yield seemed to effect the fuel consumption of the boll buggy tractor more so than that of the module builder tractor. Data was not sufficiently structured to do a statistical analysis; however, fuel consumption of different harvest systems varied very little.

Table 1: Season Long Fuel Consumption for One Cotton Harvesting Operation; 2007

# Days	Machine	Fuel/engine hr	Fuel/acre	Fuel/bale
4	JD 9976 Picker	9.62	1.85	0.83
3	JD 9976 Picker	11.33	2.06	0.86
5	JD 9976 Picker	9.78	2.09	0.82
4	JD 9976 Picker	10.57	1.89	0.98
Weighted Avg.		10.23	1.97	0.93
4	JD 4640, KBH Auto MB	2.30	0.25	0.11
3	JD 4640, KBH Auto MB	2.19	0.17	0.07
5	JD 4640, KBH Auto MB	2.05	0.42	0.16
4	JD 4640, KBH Auto MB	2.00	0.40	0.21
Weighted Avg.		2.13	0.32	0.14
4	JD 4650 KBH BB	1.57	0.31	0.14
3	JD 4650 KBH BB	2.77	0.38	0.16
5	JD 8300 6R KBH BB	3.35	0.40	0.16
4	JD 8300 6R KBH BB	1.55	0.40	0.21
Weighted Avg.		2.35	0.37	0.16
Total System		14.70	2.67	1.24

Table 2: Fuel Consumption for Eight Systems Monitored

Operation	Picker(s)	Boll Buggy	Module Builder	Total/hr	Total/ac	Total/bale
1	10.23	2.35	2.13	14.70	2.67	1.24
2	10.22	2.16	2.06	14.34	2.43	1.43
3	10.29	1.60	1.65	13.56	2.65	1.41
4	10.22	1.72	1.65	13.60	2.65	1.41
5	9.99	2.45	2.36	14.80		
6	10.24	1.99	2.36	14.59		
7	11.40	1.82	1.54	14.76		
8	11.67	2.87	1.64	16.18		
Average	10.53	2.12	1.92	14.57	2.60	1.37

Time-in-motion data (Table 3) from harvesters in 2006, shows that typical harvesters operate at approximately 70% field efficiency (time on the row picking) when operating in first gear at 3.6 mph. All systems except number 4 were operated with the boll buggy "tending" the picker by following close behind when the picker was nearly full. This allowed the picker to stop on the row, the boll buggy to reach and be ready to receive the picker dump within 10-15 seconds, and the picker to dump and resume picking within 60 to 75 seconds of the dump initiation. Harvest system number 4 operated with the picker driving to the turn row before unloading, resulting in a 49% harvesting efficiency (time on the row harvesting, not including picker field travel or servicing time).

Table 3: Harvest System Field Efficiencies at Seven Locations

		Percentages					
Location	**Clock hrs**	**On Row**	**Turn**	**Dump**	**Down**	**Wait to dump**	**Travel**
1	6:08:13	69.7	10.5	9.5	10.2		
2	3:43:06	70	17.1	5.8	7.2		
3	4:58:15	74.6	12.5	6.4	6.2	1.0	
4	10:38:15	49.4	8.6	8.5	21.7**		11.9
5	8:04:37	66.5	6.1	6.3	19.4**	1.6	
6	6:08:49	66.4	17.5	5.1	10.2		
7	4:23:58	76	9.9	4.6	7.9		
Average	6:17:53	67.51	11.74	6.60	2.6		
Average less location 4	5:34:30	70.53	14.22	7.38	8.34***		

** Included lunch
*** Less locations 4 & 5 lunches

This translates into 8.3 ac/hr theoretical picking capacity or 5.80 ac/hr actual capacity and a fuel consumption of 1.82 gallons/ac for the harvester. Those fields averaged 2.19 bales/ac. This resulted in 2.51 gallons/ac and 1.15 gallons/bale total fuel consumption for a six row picker supported with one module builder and one boll buggy.

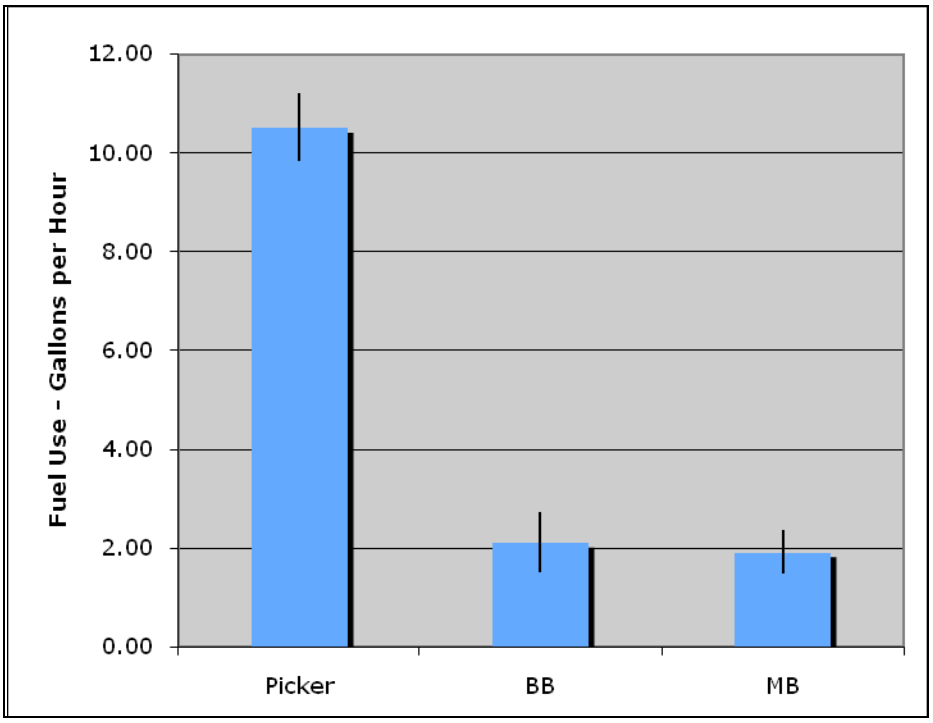

Figure 1: Harvest System Fuel Consumption for different operations.

Conclusions

Fuel consumption per harvested acre of cotton appears to have increased from 1.75 gallons/ac (gasoline) in 1942 to 2.4 gallons/ac (diesel) for two row harvesters in the mid 1960's to 1.82 gallons/ac (diesel) for the current six row basket pickers. Per bale fuel consumption has decreased due to increased yields from 4.08 gallons of gasoline per bale in 1942 to 1.20 gallons/bale with current six row pickers. The module builder and boll buggy handling systems have helped to reduce non productive time at a small additional fuel consumption of 0.72 gallons/ac or 0.33 gallons/bale.

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