DOE/EE/15637 -T3

Lisa M. Barnett, EE-521
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

February 5, 1996

RE: Energy Data, October - December 1995 Technical Progress Report
Instrument No. DE-FG01-95-EE15637, ERIP Invention 637

RECEIVED
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OSTI

Dear Lisa,

Lyle Carter has compiled the energy measurements from the two Pegasus prototypes at the USDA Cotton Research Station in Shafter, CA. Enclosed are his cover letter, a brief narrative, comparative chart, raw draft and speed data, statistical analyses, and the plot plan.

The data show that the plow version of the Pegasus should result in an energy savings of 71.3% over conventional tillage practices. The disk version of the Pegasus should save 60.4% of the energy. These savings are greater than I expected.

It is interesting to note that both versions of the Pegasus require slightly more energy to plow under unshredded stalks. For example, the plow version requires 24.46 kW.h/ha to plow under shredded stubble and 27.48 kW.h/ha to plow under standing stalks. This additional 3.02 kW.h/ha should result in a additional energy savings by eliminating the stalk shredding operation, which requires 19.0 kW.h/ha.

This mostly completes Task 2, Number 4 of the Statement of Work (we did not test in many wet situations, hopefully there will be more opportunities next year). Nevertheless, Lyle Carter and I are committed to continue with this study for another two years. We do not plan to collect more energy data, unless you deem it necessary. We plan to focus our work on the effects of whole stalk burial on the soil ecology and on any agronomic effects on the crop. We hope to expand the study to a site in the Imperial Valley, CA and to one site in Arizona.

Also enclosed are financial forms and documents which I am submitting to Michele Miskinis. With the tillage season over, I have finally found time to sit in the office and crank out paper.

Sincerely,

Gary W. Thacker

enclosures

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xc: Michele Miskinis, HR-561.21
DOE-OSTI

MASTER

UNITED STATES
DEPARTMENT OF
AGRICULTURE

AGRICULTURAL
RESEARCH
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WESTERN INTEGRATED
CROPPING SYSTEMS
RESEARCH UNIT

February 1, 1996

Gary Thacker
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Pima County Office
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Enclosed is a brief report of the energy measurements made last year at Shafter. We used published data to construct the energy used by most farmers. This value may be conservative: 1) only necessary operations were listed (farmers may use more operations depending upon soil condition, etc); 2) proper size tractors were assumed (often farmers use an available larger tractor).

Enclosed also is a diskette with two versions of the text: 1) WordPerfect DOS and 2) WordPerfect 6.1 for Windows. Use parts or all if it has any value to you.

The ANOVA showed an interesting problem with the old disc unit. The variability among plots was much greater than with the moldboard unit. Especially interesting was the distribution which indicates variable loading perhaps due to the covering disks. It is not a 'normal' distribution; there are isolated high energy values; so the mean may not indicate the expected performance.

Please call if you need more data or want to discuss the results.

Sincerely

Lyle M. Carter
Agr. Engr.

PEGASUS ENERGY REPORT

One of the cotton post-harvest operations is to dispose of the cotton stalk. Many cotton growing states mandate that the stalk root be loosened and the stalk be buried. This operation is often referred to as "plow down" and is to prevent the over wintering of the larvae of the pink bollworm.

Present farmer practices necessitate many field operations (Table 1) in order to prepare a harvested cotton field for next spring planting. All, but the re-bedding operation are timely in order to meet the state plow down date requirement. Farmers often have trouble meeting this date because of inclement weather, late harvest date, and available equipment and personnel. Present practices also preclude the use of precision tillage in which beds are maintained in their respective location in successive years.

The purpose of this field test was to evaluate stalk removal and burial equipment developed by the Pegasus Corporation. Equipment objectives were to start with a standing stalk, bury it in a slot and re-bed in the same bed location. These objectives were to be accomplished in a once-over operation. Our evaluations were to include: (1) how well the stated objectives were carried out, (2) compare energy requirements for the Pegasus equipment to that of conventional farmer practices.

PROCEDURE

Test field was located at the USDA Cotton Research Station, Shafter, Calif. and was a randomized split plot with repeated measure design. The treatments were: stalks standing, stalks shredded, irrigated and non-irrigated. Test plots were approximately 55 ft long. The field was divided into four replications with four runs per treatment.

Two types of stalk incorporators were evaluated: the "disk" unit consisted of two 50 inch diameter disks. The other unit, referred to as the "plow", used a moldboard type plow share rather than the two disks. Both units operated in a similar manner in which a slot was formed adjacent to the stalks which were folded and placed into the slot. Bedder disks were mounted behind each unit to cover the stalks and re-bed in the same bed location. Each stalk incorporator was mounted to a instrumented 3-pt. hitch tool bar for draft measurements.

Two-row prototype equipment was used for these tests. Commercial units would consist of at least 4-row and possibly 6-row equipment.

RESULTS

The non-irrigated test plots were not included in this study because of dry soil conditions. The draft requirements for both of the Pegasus stalk incorporators in some cases were such that the tractor had insufficient power. Also, because of the large draft requirements there was high probability of damaging the instrumented 3-pt hitch tool bar. Observations of the disk unit indicated difficulty in penetrating the soil to both cut a slot and to have sufficient soil to re-bed. The plow unit was able to form a suitable slot but the clods were too large and hard to re-bed. For the conventional farmer method the stalks were shredded with a 6-row rotary shredder. Stalks were lifted with a 6-row

Arizona Sundance Farms root lifter. A disk harrow was used to incorporate the shredded material. Even with two diskings there was insufficient loose soil available to re-bed at this time.

The Pegasus equipment worked much better on the irrigated plots. With adequate soil moisture both stalk incorporators did an excellent job of placing the stalks in the slot located near the center of the bed. The re-bedders did an excellent job of covering the material and reforming new beds. There were some problems of the operator being able to maintain the proper location on the beds. In these cases, the stalks were either missed and/or not covered properly in the slot. The equipment is very sensitive to proper 3-pt. hitch leveling and alignment. A row guidance device should solve these problems.

An analysis of variance indicated that there is a highly significant difference in energy requirements between the two Pagasus stalk incorporators. The increased energy required for the disk unit can be partially attributed to the design of the re-bedding disks which moved more soil than those of the plow unit. The coefficient of variance for the disk unit (15.4%) was nearly double that of the plow unit (8.2%). This probably can be attributed to the varying amounts of soil contained within the re-bedding disks.

A comparison of stalk conditions indicates that the plow unit seems to be slightly more sensitive than the disk unit. No explanation is available for this observation.

The post-harvest operations starting from standing stalk to re-bedded field are shown in Table 1. A comparison of energy inputs indicates that use of either of the one pass Pegasus stalk incorporators should result in significant savings when compared to the multiple pass operations necessary for the conventional farmer method. Use of the plow unit should result in energy savings of 71.3%, whereas the disk unit should save 60.4%.

TABLE 1. COTTON POST-HARVEST OPERATIONS

<u>Pegasus</u>		<u>Conventional</u> ¹	
Equip./Operation:	kW.h/ha	Operation:	kW.h/ha
1. Plow -lift & fold	27.48	1. Cut stalks	19.0
stalks into slot		2. Lift roots	12.7
and re-bed		3. Disk 2X	35.0
-or-		4. Re-bed	<u>25.8</u>
2. Disk -same operation	36.61	Total:	92.5
as plow			

¹Calif. Cotton Review vol. 38, pg 4, December 1995

COTTON POST-HARVEST ENERGY

General Notes:

1. SPEED: Ford TW-5, 2nd gear (Rabbit) @ 1800RPM 18.4R-38 tires
2. DEPTH: No control for disk unit = deep!
3. Top link too short causing instability of depth; lengthed between plots 7 & 8
4. Only irrigated plots assigned. Original condition judged inappropriate for application of either Pegasus design - too dry or hard
5. At plot #50 discovered 3-pt hitch was not floating (plots 33-49 rigid lower link)
7. Plots 1-32 Disk; plots 33-64 Plow
8. Prep.- Stalks: shredded (shred), standing (stand)
9. * Time averaged from within rep.

Summary Table 1

	ALL	SHRED	STALKS
		kW.h/ha	
Disk	36.54	36.50	36.81
Plow	25.92	24.46	27.48

PASS	REP	TRT	MACH	PREP	TIME (sec)	PLOT	SPEED (MPH)	DRAFT (Lbs.)	HP	ENERGY (kW.h/ha)	COMMENTS
1	1	D	shred	13.4	51.5	2.82	6299	44.01	38.30		Start of disk test
2	1	D	shred	15.37	51.5	2.26	7161	43.62	43.54		missed stalks in last 1/4 of plot - unit went deep
3	1	D	shred	13.94	51.5	2.52	7154	48.04	43.50		
4	1	D	shred	13.24	51.5	2.65	6875	48.81	41.81		
5	1	D	stand	13.98	52	2.54	7837	52.99	47.66		
6	2	D	shred	17.16	54	2.15	8103	45.35	49.27		speed reduced- went too deep
7	2	D	shred	14.91	* 54	2.47	5091	33.52	30.96		changed top link: lengthened 4 turns raised depth
8	1	D	stand	12.4	52	2.88	6775	51.85	41.20		depth slightly deeper than #7 performance judged ok
9	1	D	stand	13.12	52	2.70	5516	39.74	33.54		
10	2	D	shred	14.06	54	2.62	5997	41.87	36.47		
11	2	D	shred	13.52	54	2.72	5977	43.39	36.35		
12	1	D	stand	13.08	52	2.71	6441	48.55	39.17		
13	2	D	shred	13.53	54	2.72	5169	37.50	31.43		
14	3	D	stand	12.94	53	2.79	5739	42.73	34.90		
15	3	D	stand	12.75	53	2.83	5249	39.66	31.92		
16	2	D	shred	13.53	* 53.5	2.70	6117	43.97	37.20		
17	2	D	shred	13.4	53.5	2.72	5169	37.51	31.43		
18	3	D	stand	13.1	53	2.76	5683	41.79	34.56		
19	3	D	stand	16.7	53	2.16	4920	29.38	29.92		speed problem - driver oriented
20	2	D	shred	13.66	53.5	2.67	6266	44.81	38.10		
21	3	D	shred	13.13	* 53	2.75	4896	35.92	29.77		
22	4	D	shred	13.66	54	2.69	7792	55.99	47.38		disk problem- large disks loaded at beginning of plot carried through
23	4	D	shred	13.66	54	2.69	5118	36.78	31.12		same loading
24	3	D	shred	13.06	53	2.77	4990	36.81	30.34		same loading
25	3	D	shred	13.31	53	2.71	5103	36.94	31.03		same loading
26	4	D	shred	12.74	54	2.69	5501	42.38	33.45		flow ok
27	4	D	shred	13.06	54	2.82	5041	37.89	30.65		flow ok
28	3	D	shred	13.03	53	2.77	6221	46.00	37.83		
29	4	D	stand	13.22	51.5	2.66	6856	48.55	41.69		
30	4	D	stand	13.02	51.5	2.70	6615	47.56	40.22		
31	4	D	stand	12.84	51.5	2.73	6925	50.49	42.11		
32	4	D	stand	13.34	51.5	2.83	7140	50.11	43.42		
33	1	P	shred	13.37	51.5	2.63	3803	25.23	21.91		Start of moldboard test
34	1	P	shred	13.02	* 51.5	2.70	4000	26.76	24.32		
35	1	P	shred	13.06	51.5	2.69	3887	27.86	23.64		
36	1	P	shred	12.63	51.5	2.78	3707	27.48	22.54		
37	3	P	shred	12.99	53	2.78	3715	27.55	22.59		
38	4	P	shred	13.37	54	2.75	3805	27.94	23.14		
39	4	P	shred	13.16	54	2.60	3645	27.19	22.16		
40	3	P	shred	13.04	53	2.77	4153	30.68	25.25		
41	3	P	shred	13.04	53	2.77	4185	30.92	25.45		
42	4	P	shred	13.24	54	2.78	4526	33.56	27.52		
43	4	P	shred	13.3	54	2.77	4096	30.23	24.91		
44	3	P	shred	12.96	53	2.79	3880	28.87	23.59		
45	2	P	stand	13.87	53.5	2.63	4112	28.83	25.00		
46	3	P	stand	13.49	53	2.68	4815	32.96	26.06		
47	3	P	stand	13.21	53	2.73	4360	32.02	26.69		
48	2	P	stand	13.9	53.5	2.62	4485	31.38	27.27		
49	2	P	stand	13.96	53.5	2.61	4517	31.47	27.47		
50	3	P	stand	13.29	53	2.72	4814	34.90	29.27		changed 3-pt hitch to floating- because of poor performance
51	3	P	stand	0	* 53	0.00	0	0.00	ERR		no data readjusting links
52	2	P	stand	15	53.5	2.43	4427	28.70	26.92		
53	1	P	stand	13.05	52	2.72	4418	32.00	26.87		
54	2	P	shred	13.56	54	2.71	4023	29.12	24.46		
55	2	P	shred	14.3	54	2.57	4294	29.48	26.11		
56	1	P	stand	13.2	52	2.69	4485	32.12	27.27		
57	1	P	stand	13.26	52	2.67	4635	33.04	26.18		
58	2	P	shred	13.5	54	2.73	4286	31.16	26.06		
59	2	P	shred	13.66	54	2.69	4557	32.75	27.71		
60	1	P	stand	13.31	54	2.77	4564	33.88	27.94		
61	4	P	stand	13.43	51.5	2.61	4383	30.55	26.65		
62	4	P	stand	13.06	51.5	2.69	4481	32.12	27.25		
63	4	P	stand	12.99	51.5	2.70	4563	32.88	27.75		
64	4	P	stand	13.4	51.5	2.62	4864	33.98	29.58		

Analysis of Variance Procedure
Class Level Information

Class Levels Values

REP 4 1 2 3 4
MACH 2 D M
PREP 2 N Y

Number of observations in data set = 64

NOTE: Due to missing values, only 63 observations can be used in this analysis.

Analysis of Variance Procedure

Dependent Variable: DRAFT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	66149507.513	7349945.279	20.18	0.0001
Error	53	19304132.137	364228.908		
Corrected Total	62	85453639.651			

R-Square C.V. Root MSE DRAFT Mean
0.774098 11.59609 603.51380 5204.4603

Source	DF	Anova SS	Mean Square	F Value	Pr > F
REP	3	3384850.792	1128283.597	3.10	0.0345
PREP	1	567333.466	567333.466	1.56	0.2175
REP*PREP	3	6031332.553	2010444.184	5.52	0.0023
MACH	1	54124557.715	54124557.715	148.60	0.0001
MACH*PREP	1	2041432.987	2041432.987	5.60	0.0216

Tests of Hypotheses using the Anova MS for REP*PREP as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
PREP	1	567333.46561	567333.46561	0.28	0.6321

T tests (LSD) for variable: DRAFT

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 364228.9

Critical Value of T= 2.01

Least Significant Difference= 308.18

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 30.85714

T Grouping	Mean	N	PREP
A	5314.0	27	N
A			
A	5122.3	36	Y

T tests (LSD) for variable: DRAFT

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 364228.9

Critical Value of T= 2.01

Least Significant Difference= 305.05

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 31.49206

T Grouping	Mean	N	MACH
A	6116.8	32	D
B	4262.7	31	M

Level of MACH	Level of PREP	N	-----DRAFT-----	
			Mean	SD
D	N	12	6308.00000	875.461437
D	Y	20	6002.00000	986.749422
M	N	15	4518.86667	181.165617
M	Y	16	4022.62500	297.797218

Analysis of Variance Procedure
Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
MACH	2	D M
PREP	2	N Y

Number of observations in data set = 64

NOTE: Due to missing values, only 63 observations can be used in this analysis.

Analysis of Variance Procedure

Dependent Variable: HP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	3038.1154944	337.5683883	22.68	0.0001
Error	53	788.9386135	14.8856342		
Corrected Total	62	3827.0541079			

R-Square	C.V.	Root MSE	HP Mean
0.793852	10.42522	3.8581905	37.008254

Source	DF	Anova SS	Mean Square	F Value	Pr > F
REP	3	159.1988659	53.0662886	3.56	0.0201
PREP	1	30.8227811	30.8227811	2.07	0.1560
REP*PREP	3	274.7774306	91.5924769	6.15	0.0011
MACH	1	2480.8721175	2480.8721175	166.66	0.0001
MACH*PREP	1	92.4442993	92.4442993	6.21	0.0159

Tests of Hypotheses using the Anova MS for REP*PREP as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
PREP	1	30.82278108	30.82278108	0.34	0.6025

T tests (LSD) for variable: HP

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 14.88563

Critical Value of T= 2.01

Least Significant Difference= 1.9701

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 30.85714

T Grouping	Mean	N	PREP
A	37.8159	27	N
A			
A	36.4025	36	Y

T tests (LSD) for variable: HP

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 14.88563

Critical Value of T= 2.01

Least Significant Difference= 1.9502

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 31.49206

Means with the same letter are not significantly different.

T Grouping	Mean	N	MACH
A	43.1847	32	D
B	30.6326	31	M

Level of MACH	Level of PREP	N	Mean	SD
D	N	12	45.0166667	6.96572561
D	Y	20	42.0855000	5.50639865
M	N	15	32.0553333	1.73889072
M	Y	16	29.2987500	2.17193884

Analysis of Variance Procedure
Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
MACH	2	D M
PREP	2	N Y

Number of observations in data set = 64

NOTE: Due to missing values, only 63 observations can be used in this analysis.

Dependent Variable: ENERGY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	2446.4857398	271.8317489	20.19	0.0001
Error	53	713.6537459	13.4651650		
Corrected Total	62	3160.1394857			

R-Square	C.V.	Root MSE	ENERGY Mean
0.774170	11.59502	3.6694911	31.647143

Source	DF	Anova SS	Mean Square	F Value	Pr > F
REP	3	125.2249249	41.7416416	3.10	0.0344
PREP	1	21.0166700	21.0166700	1.56	0.2170
REP*PREP	3	223.1137159	74.3712386	5.52	0.0022
MACH	1	2001.6095889	2001.6095889	148.65	0.0001
MACH*PREP	1	75.5208401	75.5208401	5.61	0.0216

Tests of Hypotheses using the Anova MS for REP*PREP as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
PREP	1	21.01666997	21.01666997	0.28	0.6319

T tests (LSD) for variable: ENERGY

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 13.46517

Critical Value of T= 2.01

Least Significant Difference= 1.8738

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 30.85714

T Grouping	Mean	N	PREP
A	32.3141	27	N
A			
A	31.1469	36	Y

T tests (LSD) for variable: ENERGY

NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.

Alpha= 0.05 df= 53 MSE= 13.46517

Critical Value of T= 2.01

Least Significant Difference= 1.8548

WARNING: Cell sizes are not equal.

Harmonic Mean of cell sizes= 31.49206

T Grouping	Mean	N	MACH
A	37.1950	32	D
B	25.9203	31	M

Level of MACH	Level of PREP	-----ENERGY-----		
		N	Mean	SD
D	N	12	38.3591667	5.32385277
D	Y	20	36.4965000	6.00007568
M	N	15	27.4780000	1.10244015
M	Y	16	24.4600000	1.81075307

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