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המרכז למחקר בכלכלה חקלאית

THE CENTER FOR AGRICULTURAL ECONOMIC RESEARCH

Working Paper No. 9805

A COMPUTER IN THE MILKING PARLOR

by

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The authors thankfully acknowledge the cooperation of the Yavneh herdsmen, the Afimilk development team and the advice of Y. Yahav, O. Markusfeld-Nir, A. Saran, A. Berman, and E. Ezra—generously offered throughout the study. Barbara Kohn read an earlier draft of the manuscript and made several important suggestions. The authors are of course solely responsible for remaining errors.

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A COMPUTER IN THE MILKING PARLOR

Abstract

In this paper we report an experiment conducted to assess the contribution of a computer system in the milking parlor to detection of mastitis and estrous (udder infection and the time to inseminate the cow). The experiment was carried out in a 700 cow herd in Israel. It was found that the computer system contributed significantly to productivity and profitability of the dairy enterprise.

(key words: precision farming, computers in agriculture, dairy economics, milk production, management information systems, mastitis, estrous)

The use of computers and innovative information technology in agriculture—including the application of sophisticated georeferencing methods—has been gaining ground, but the economic implications of these modern developments are seldom quantified. For example, no empirical assessments of cost or benefits were presented in the session devoted to precision farming and the new information technology in the 1996 annual meeting of the American Agricultural Economic Association (although Lowenberg-DeBoer mentioned several studies in the discussion of the papers presented in the session). The studies that did attempt to quantify the impact of the new technology either analyzed the characteristics of the adopting farmers (Putler and Zilberman) or assessed the benefits by comparing the performance of farms with computers to those without; examples are, Verstegen, Dijkhuizen, Huirne, and Renkema in pig production and Lazarus, Streeter and Jorfe-Giraudo in dairy. Agricultural scientists discussed the technical aspects and potentials of computer systems; example, Allore, Jones, Merill, and Oltenacu.

In this paper we report on direct measurement of the contribution of a computerized information system in dairy. We focus on two major areas: mastitis detection and identification of estrous. The first is udder infection, estrous is the time the cow is in heat and ready for insemination. Both occurrences are economically significant events in dairy herds requiring accurate identification and timely attention. The study was conducted in a large dairy herd in kibbutz Yavneh, a communal farm in Israel.

The major findings suggest that the computerized Management Information System contributed to reducing mastitis milk losses and, by facilitating better estrous detection, improved the timing of insemination. The annual benefit in Yavneh after the first year of adoption was close to $70 per cow and the repayment period for the investment in the system was three years.

The paper opens with a short introductory discussion of mastitis, estrous and a computerized dairy management information system. The empirical core of the study is presented in the sections reporting the findings for the Yavneh herd analysis. The paper concludes with an economic estimate of the contribution of the computerized information system.

Mastitis

Mastitis is a generalized term for a wide range of udder infections. Mild cases cause short term loss of milk yield and reduction in its quality, but losses may be of long duration and in severe cases cows have to be culled. The infection may be and has been detected by visible symptoms, on sight. Early detection enables timely treatment, reducing or even preventing mastitis related losses.

For the duration of the infection, mastitis-affected cows are milked separately, sometimes by hand, and the milk discarded. In addition, even after recuperation from the acute infection, normal yield levels are recovered only gradually. Accordingly, we distinguish between <u>direct</u> milk loss—reduced production and discarded milk for the duration of the mastitis incident; and <u>indirect</u> loss—long term yield reduction. The combined loss of milk production is the major damage caused by mastitis in cows that do recover. Additional mastitis related losses include the cost of extra labor required to milk separately or by hand, medicine, if applied, and a penalty for low quality milk. Quality is affected if mastitis is not detected and milk from infected cows goes into the parlor's milk tank. One of the prime tasks of the dairy operator is to minimize these losses; early detection and accurate information on the affected cow's condition and history are crucial prerequisites. Computer connected electronic devices measure and record the electrical conductivity of the milk; mastitis is then indicated by deviations from normal conductivity. These deviations may be identified before the observation of visible symptoms.

Estrous

Estrous is the period of heat. Accurate detection and consequent insemination increase the probability of timely and successful conception. Estrous can be detected by visible symptoms: unrest, mounting and vaginal discharge. Identified cows are examined and inseminated if found to be in heat. Some cows may not display visible signs of heat—this is an anestrous condition. In these cases, days from last calving are counted and the cows are inspected by the veterinarian to determine estrous or cause of its absence. Unidentified estrous reduces the probability of timely insemination, increases the number of unintended and unproductive open days (days between calving), reduces milk yield, and may result in culling of high yielding cows.

Computer identification of estrous is based on activity measurements. Cows carry foot tags with pedometers by which they are identified in the milking stall. The pedometers count steps, the numbers are transmitted to the computer and the hourly averages recorded. Deviations are marked as unrest, suspected estrous and possible ill health. The system installed in kibbutz Yavneh at the time of the study could indicate heat in cows that had calved at least once. Modern (1997) systems may detect estrous also in calves before their first calving.

Afimilk System

Afimilk is the trade name of a dairy parlor information system partly produced and assembled in Israel. Such systems include a PC and electronic devices which identify cows, monitor their production variables, keep records and provide information to assist decision making. Afimilk was first introduced experimentally in 1986 and by now, more than 50% of the large herds in the country have installed the system. Two other computerized systems are used in a small number of herds. Afimilk performs the following functions:

1. identifies cows in the milking stalls;
2. monitors the cow's milk flow and yield;
3. measures electrical conductivity of milk and indicates suspected mastitis;
4. records unrest and indicates estrous.

The system reports three times daily, summarizes data on call and flashes abnormal findings. Parameters for significance levels of tests of deviations can be fine-tuned by season or cow's conditions.

The experiment

Kibbutz Yavneh, where the study was conducted, is located on the coastal plain in Israel. The kibbutz operates several farm enterprises, among them a dairy of close to 700 cows. Milk marketing is controlled by a Marketing Board—kibbutz Yavneh's quota is 3,000,000 kg per year. This quantity is paid a regulated price (affected by quality); "surplus," above quota production, is paid much lower prices. Milking is done three times a day and yields in Yavneh are relatively high; at the time of the study, annual yield was above 10,000 kg per cow for an average of 32 kg per day for a 305 day lactation. The previous dairy parlor computer system was changed to Afimilk in June, 1993 when the study began. For the dairy team, experienced with the former system, the transition was smooth (it lasted one week) with no significant changes in management and decision procedures. The team cooperated willingly with the research project.

The milking cows were divided, with the introduction of Afimilk and the commencement of the study, into a trial group and a control group. The information provided by Afimilk and used for mastitis and estrous detection was made available to the dairy operators only for the trial group. The information for the control group was blocked at the source. Consequently, the herdsmen received just three yield measurements per day for the control cows, whereas additional 9 measurements were available for the cows in the trial group (steps per hour, rate of milk flow and electrical conductivity of the milk for each of the three milking sessions). Without this additional information the operators had to rely, in the control group, on conventional methods of mastitis and estrous detection. The cows from both groups were mixed in the cow sheds, group identity was masked and all cows were treated similarly.

The field study covered 18 months, from June 1993 until December 1994. In this way, full lactation of all cows in the study were covered. Each cow's milk yield and other parameters were measured and recorded three times a day. For cows that had mastitis, direct daily milk loss was calculated, from the day of detection until the cow was considered mastitis-free, as the difference between the average daily yield for the last 4 days before identification and the actual daily measurement at the time the cow was infected. The magnitude of the indirect loss is difficult, if at all possible, to estimate for individual cows as relatively higher yielding cows are more susceptible to mastitis. Therefore we estimated the indirect loss by differences in the groups (trial and control) between the average yield of the infected and that of the uninfected cows. The effect of estrous detection was measured in open days (the days between calving and confirmed conception). The contribution of the Afimilk system was calculated as the value of the difference in milk production and average open days between the trial and the control herds.

Although the Yavneh herd could be taken as the universe of the study population, statistical significance is reported as if the measured magnitudes were a random sample from the national herd (or a single year from a yearly time series of the Yavneh herd).[1] This makes for stricter evaluation of the results.

The division of the herd

The milking cows in Yavneh were divided into trial and control groups. Cows about to be culled were not included in the study. The selection was stratified by the following variables: lactation, calving related diseases, number of days from calving and projected milk yield. The stratification was lexicographic; that is, the cows were assigned into one of three categories by lactation—first, second or higher; each of these were divided again for calving related diseases—yes or no—adding two categories for a total of 6, then again assignment was repeated within each category into an additional six categories by days from last calving. The process ended with 606 cows in the study equally divided between the trial and the control groups.

Mastitis detection

The total number of mastitis incidents during the time of the study was 316; of these, 116 were in the control group and 200 in the trial group (Table 1, in which, it is worth noting, all the differences between the groups are statistically significant). These incidents occurred in 170 cows; some cows suffered from the infection more than once during the period of the study while others did not show mastitis symptoms at all. Such differences can be expected, certain cows are more inclined to develop mastitis than others; but as our analysis was concerned with detection, we regarded each incidence as a separate independent realization, whether such incidents occurred once or several times for the same cow. Assuming that the groups did not differ systematically (an assumption to be corroborated by findings below), the larger number of identified

[1] With centrally coordinated artificial insemination, average genetic yield potentials of all herds are essentially identical. Individual cows (phenotypes) naturally vary in performance. Differences between herds are also substantial, probably due to management and local conditions.

cases in the trial group indicates more accurate detection of the computer supported system than on sight.

Not all the incidents were included in the statistical analysis to follow. Cows in the first 10 days of milking as well as cows in the last 5 days of lactation were excluded since it was impossible to estimate the yield effect of mastitis in these stages. Incidents which lasted less than 24 hours were also not included. Deleting these cases, 220 incidents were analyzed, 90 in the control and 130 in the trial group.

Table 1 reports two additional statistics: the average duration of incident in the control group was 4.4 days as against 3.9 days for the trial group. Electronic monitoring both assisted in early detection and may have flagged cases which might have gone unnoticed. Early detection leads to immediate treatment, where necessary, and a shorter duration. An additional benefit was that medical treatment, when applied, was less intensive.

Table 1. Mastitis detection

n = 606	Total	Control	Trial	Stat. sig.
Number of mastitis infected cows	170	74	96	$p<0.05$
Number of incidents	316	116	200	$p<0.05$
Number of analyzed incidents of these	220	90	130	$p<0.05$
mastitis incident duration (Mean ±SD)		4.42±2.14	3.94±2.42	$p<0.05$
% of medically treated incidents		86.6	78.5	$p<0.05$

In Table 2 we divide the incidents by length and report direct milk loss (yield loss in the period of infection). Consistently with the shorter average duration reported in Table 1, there were more short term incidents (2-3 days) in the trial than in the control group and fewer long term cases. The differences in milk loss per day were not significant but the overall loss per incident— 65.1 kg per cow in the control and 44.8 in the trial group—were significantly different from each other.[2] As already indicated with respect to Table 1, the differences between the trial and the control groups in Table 2 reflect more accurate detection and timely treatment. If, in addition, some control group cases were undetected, the differences in milk loss underestimate the contribution of the computer system: when mastitis is undetected, lower quality milk is not discarded and the dairy is penalized.

Table 2: Mastitis incident duration and direct yield reduction

	Number of incidents		Loss per incident kg/cow (Mean±SD)		Stat. sig.
Incident duration	Trial	Control	Trial	Control	
2-3 days	70	38	21.3 ±19.9	24.6 ± 18.2	n.s.
4-5 days	37	28	57.4 ± 54.3	61.3 ± 58.9	n.s.
6-10 days	20	24	103.9±72.8	133.6±101.8	n.s.
Overall	127	70	44.8±10	65.1±52.9	$p<0.05$

Note: milk loss is in kg per cow.

In Table 3 we report total milk loss, direct plus indirect. The reporting is by group and sub-group: trial and control groups, cows with mastitis and cows without, and within the groups by length of lactation—cows that were milked more than 270 days (Days In Milk, DIM) but less than 305 DIM were grouped under the 270 DIM heading, cows with more than 305 days of milking were grouped under the 305 DIM heading. Cows

[2] Not all mastitis cases were cured. The prevailing policy was to cull cows that were not cured in 10 days. Accordingly, two trial and four control cows were culled. They were included in Table 2 in the 6-10 days category. Three other cows in the experiment group were treated as special cases. These were high yielding cows that, following severe mastitis and early detection and medical treatment, the Yavneh team decided to save and left them in the herd for longer periods: 12, 13, and 18 days. Their average direct milk loss was 352 kg. They were not culled, but being special cases, were not included in the report of Table 2. In addition, 6 cows from the trial group and 14 from the control were culled due to low yield.

that did not reach 270 DIM were not included in the loss estimates of Table 3. For comparison, the lactation yield of a cow was taken as her lactation for the indicated days; for example, yield for the first 270 days was taken for the cows in the 270 DIM (and not the total amount of milk they gave for the whole length of the period of lactation). As indicated earlier, the loss estimates were prepared at the group and sub-group level. The numbers in the table are averages per cow in group for the lactation yield; for example, there were 29 cows with mastitis in the trial group with 305 DIM average sub-group yield of 10,896 kg milk per cow; similarly, 21 cows with mastitis in the control group yielded an average for 305 DIM of 10,387 kg per cow.

Table 3: Comparison of yields by Days In Milk (kg per cow)

n = 606	Less than 270 DIM	Average in herd		Cows without mastitis		Cows with mastitis	
Lactation days		270	305	270	305	270	305
Trial group yield		9270	10606	9184	10513	9661	10896
Number of cows	28	156	119	128	90	28	29
SD		±1090	±1425	±1061	±1499	±1154	±1140
Control yield		9075	10289	9121	10290	8835	10387
Number of cows	39	152	112	127	88	25	21
SD		±1248	±1182	±1258	±1236	±1185	±981
Yield difference in trial's favor		195	317	63	223	826	615
Stat. Signif.		n.s	p<0.05	n.s	n.s.	p<0.05	p<0.05

Several points are worth noting. Yields of cows without mastitis in the trial and control were not significantly different; the Yavneh herd was divided to groups of similar average yield. The yield differences for cows with mastitis were statistically significant, reflecting, we repeat, timely detection and treatment in the trial group. Note also, that for the four comparisons (trial and control and 270 and 305 DIM), the yield of most of the mastitis infected cows was equal or higher than for the non-infected: high-yielding cows are comparatively more susceptible to infection (similar findings are reported by Houben et al and Lucy and Rowlands). The data of Table 3 will be used in the economic analysis below.

Estrous detection

Table 4 summarizes the major findings for the 352 cows that fitted into the study's 18 months schedule and with pregnancies of less than 150 open days. Delayed impregnation—defined as having more than 150 open days—is usually caused by problems unrelated to inaccurate estrous detection; such as reproductive system malfunction and diet deficiency disorders. These pregnancies and the explanation of their greater open day differences are beyond the scope of this study.

As the data in Table 4 indicates, there was no difference in the conception rate between the trial and the control groups, it was 31.5% for each group. Once estrous was detected and the cows

Table 4: Conception rates and open days

n=352	Control	Trial	Difference	Stat. sig.
Number of cows	180	172	8	
% examined for anestrous before insemination	35.5	20.3		p<0.05
Conception rate (%)	31.5	31.5	-	
Pregnancies with <150 open days	111	125	14	
(%)	(61.6)	(72.6)		p<0.05
Open days (Mean ± SD)	114.3 ± 48.0	111.1 ± 52.5	3.2	n.s.

inseminated, control and trial cows reacted in the same way. There were however significant differences in anestrous cases (cases in which heat was not detected but estrous suspected by day counting) and in the number of open days. By both measures, cows in the trial group, with 20.3% anestrous and 111.1 open days, did better than those in the control group. We have also found, but not reported in Table 4, that the differences between the trial and the control groups increased with age. It is more difficult to detect estrous in older cows and the electronic devices are, therefore, comparatively more important for these cows.

Benefits and costs

Computer detection reduced milk losses due to mastitis and open days of milking cows. The calculation of the benefits in our experiment was based on data gathered from the extension service of the Ministry of Agriculture (Rosen and Yechieli, 1995) and were converted to US dollars at the prevailing rate of the study time, 3.02 NIS per dollar:

Gate price of 1 kg standard quality milk	$0.36
Cost avoided	0.10
Net value of 1 kg milk loss prevented	0.26
Value of open day prevented	3.14

The cost avoided is the cost of feed conventionally attributed to marginal milk production, above body maintenance. Although it is questionable whether infected cows ate less because of the reduction in yield, we deducted this element of cost to stay within conservative bounds of estimated prevention of milk losses.

Table 5 reports the benefits per cow in the herd in Yavneh. Milk loss prevented, 248 kg, was calculated as the weighted average for yield difference in trial's favor in Table 3 (for average in herd). The number for average open days is from Table 4. Total benefits per cow are $69.60. The information generating equipment needed to perform the tasks we considered—mastitis identification and estrous detection—is optional, it may be added to the basic equipment in the milking parlor and milk recording facilities. In Yavneh, the investment for the additional equipment was $200 per cow (it would be markedly less today). This includes foot tags, milk meters, data transmission components, monitoring equipment, installation and setup. The repayment period is therefore less than 3 years; or, alternatively, for a system expected to last 5 years, the internal rate of return is 27 percent.

Table 5: Gross benefits (per cow in herd)

	Differential benefit	Measured for Yavneh
Prevented milk loss	$64.48	248 kg
Reduced open days	$ 5.12	3.2. days
Total benefits	$69.60	

Concluding remarks

We have reported an experiment in one herd. The findings clearly indicate a favorable benefit-cost ratio, even if the system would last in the milking parlor for only a few years, as so often happens with modern equipment. Several comments are now in order.

The cost per cow will be larger for smaller herds. The benefits, on the other hand, could increase with size and with the difficulty to recognize individual cows and their particular problems. Kibbutz herds are relatively large. The conclusion may be different for family farms with 30 - 50 cows.

The human factor is of great importance in livestock enterprises, and Yavneh, as indicated, has a dedicated group of workers, professional and motivated. It may well be that the contribution of the computer system would be greater with an average team. Particularly, one may expect the share of the contribution of estrous identification to be larger in many other dairies. Also, it is often claimed that the benefits of a computer system should be attributed to improved management practices in teaching operators the significance of even minor nuances in livestock behavior and performance. This component was probably only of minor importance in Yavneh and, still, as our findings indicate, the computer system contributed substantially to profitability of milk production in the kibbutz.

We attributed benefits only to losses prevented in milk and open days. But these are not the only benefits; for example, early detection of mastitis and accurate identification of estrous may reduce culling of problematic, often high-yielding, cows. We similarly did not include in the benefits the prevention of discarded milk of mastitis infected cows, labor of milking by hand the infected udder, and the cost of medicine prevented.

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