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SUPPLEMENTAL LIGHT INCREASES MILK YIELD IN MICHIGAN DAIRY HERDS

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Exposing dairy cows in Michigan to supplemental lighting in addition to natural daylight can increase milk production within a herd, according to research findings from studies conducted at Michigan State University.

Several studies conducted in recent years have focused on whether exposure to light beyond normal daylight hours during fall and winter months would affect dairy cows' production of milk and milk fat percentage. Results from a recent study indicate that dairy cows exposed to 16 hours of fluorescent lighting per day during fall and winter months produce an average of 7 to 10 percent more milk than cows exposed to normal amounts of light.

The Michigan dairy farmer may benefit from such a supplemental lighting program. This bulletin focuses on information from a recent MSU study on supplemental lighting effects on dairy cows, and explores economic factors of such a lighting program for the Michigan dairy farmer to consider. In addition, some tips are included for dairy farmers interested in setting up a supplemental lighting program on their farms.

MSU Study Tests 13 Michigan Dairy Herds

From October 1982 through March 1983, 216 Holstein, Jersey and Brown Swiss cows from 13 Michigan dairy herds were exposed to supplemental lighting of about 16 hours per day from fluorescent lamps installed in the cattle's housing facilities. Eight-foot, two-tube, fluorescent light fixtures (equipped with winter ballasts to accommodate Michigan's severe winter climate) were installed in stanchion barns on the 13 farms at the rate of one fixture for every four cows. Two types of fluorescent lighting lamps were used: cool-white fluorescent lamps, which provide approximately 100 watts per lamp, on six farms; and simulated-sunlight fluorescent lamps, approximately 100 watts per lamp, on seven farms. The type of fluorescent lamp used did not appear to make a difference. Time clocks were installed to turn the lamps on and off automatically at the start and end of the 16-hour period.

In contrast, 240 control herdmates within these herds received only the sunlight that entered naturally through windows, vents and doors during these months, plus lighting for usual management activities, such as feeding and milking. Total amount of light exposure for these control cows ranged from about 9 to 12 hours per day. All cows were housed in tie-stall or stanchion barns and were kept indoors except for normal, short-duration activities, such as exercise and heat detection. In addition, all cows in the study had been lactating at least eight weeks, and within individual herds, all cows were subjected to the same temperature conditions. An increase in feed intake of up to 6 percent has been noted in similar studies, but in this particular study, feed intakes were not measured.

After adjustments were made for differences in feeding, stage of lactation, lactation number and pre-trial milk yield, the results pooled from the 13 herds showed that cows exposed to supplemental light produced 8 percent more milk per day than herdmates exposed to natural light.

The increase in production was paralleled by a decrease in fat percentage of 0.16. Other studies have shown, however, that milk fat percentage is unaffected by lighting, while one study even showed a 0.3 percent increase in fat when supplemental lighting was used. Thus, the effects of light on milk fat percentage are controversial.

Economic Aspects of Supplemental Lighting

The study discussed in this bulletin and other studies have shown that supplementing a dairy herd's exposure to natural light (photoperiod) with artificial lighting increases milk production. The use of supplemental light to aid production of other types of animals is common. The poultry industry, for example, has recognized for many years that increasing day length helps chickens achieve maximum egg production.

But how much money is involved to install such a supplemental lighting program for dairy herds? More importantly, would such an investment pay off, and after how much time?

Table 1 outlines the potential costs involved. Regardless of herd size, daily costs per cow would amount to about 30 cents. These costs are attributed primarily

to increased feed intake and the power needed to operate fluorescent light fixtures, based on current kilowatt-per-hour (kwh) rates. The cost of electricity needed to run this supplemental lighting program is low—only 8 cents per kwh. Daily income would be 46 cents per cow, based on 1986 milk prices and a projected 8 percent increase in milk yield.

After determining daily costs (30 cents) and income (46 cents), the daily net (profit) amounts to 16 cents per day per cow.

Other costs to consider are also outlined in Table 1. This includes costs for newly purchased light fixtures, an automatic time clock and labor provided by a licensed electrician to install light fixtures on the dairy farm. Prices are based on cost per cow for herd sizes ranging from 20 to 200 cows.

How long would it take for such an investment to pay for itself? A 200-cow herdowner could expect to pay off the initial investment within 313 days, while the farmer with a 20-cow herd would break even in 345 days (see Table 1). In Michigan, supplemental lighting is recommended for use during the fall and winter months only, because duration of natural light is nearly 16 hours during the spring and summer. Thus, the costs of the lighting program can be paid in full in two winters or less.

Would A Supplemental Lighting Program Fit Into Your Farm's Plans?

The dairy farmer interested in exploring the possibility of setting up a supplemental lighting program no doubt will have many questions. The following section provides answers to some basic questions. Dairy farmers wanting further guidance in setting up a supplemental lighting program should contact their county Cooperative Extension Service office.

Q. How do I know whether the different types of lighting on my farm are appropriate for a supplemental lighting program?

A. On most dairy farms, both incandescent and fluorescent lights are already used in barns, milking

TABLE 1: Itemized income and costs from 16 hours of supplemental light for dairy herds.

Affected factor, per cow	Daily income	Daily cost
8 percent increase in milk yield[1]	$.46	
0.16 percent decrease in milk fat[2]		$.13
6 percent increase in feed intake[3]		.10
Power needed to operate an 8-ft light fixture for 16 hr[4]		.07
TOTAL	$.46	$.30
Net	$.16	

Fixed costs for cows in stanchion barns	Herd size:	Cost per cow 20	40	100	200
8-ft dust-and-moisture-resistant, rapid-start, high-output light fixture ($180 @ 1 per 4 cows)		$45.00	$45.00	$45.00	$45.00
Automatic timer ($85)		4.25	2.13	.85	.43
Labor (licensed electrician @ $30/hr)		6.00[a]	6.00[b]	4.80[c]	4.80[d]
TOTAL		$55.25	$53.13	$50.65	$50.23

PAYOFF TIME NEEDED FOR FIXED COSTS: $\frac{\$55.25}{.16}$ = 345 days; $\frac{\$50.23}{.16}$ = 314 days Range: 314 to 345 days.

[1]Based on 50 lb/day at $11.60 cwt
[2]Milk fat differential, $.16/cwt for each 0.1 percent under 3.5 percent
[3]$1.68/day for 1400 lb cow producing 50 lb/day
[4]Two lamps/fixture, 110 watts each at $.08/kwh

[a]4 hr estimated labor time
[b]8 hr estimated labor time
[c]16 hr estimated labor time
[d]32 hr estimated labor time

parlors and milk rooms. Incandescent lamps generally are used when light is needed for short periods of time and when lamps are turned on and off frequently. These fixtures are limited in the maximum intensity of light that they can put out, and increasing the wattage may result in high temperatures, fire hazards and reduced lamp life.

Fluorescent light fixtures, which provide more light per unit of energy than incandescent fixtures, are used routinely in research conducted at MSU. Rapid-start, dust- and moisture-resistant, high-output fluorescent fixtures, such as those outlined in Table 1, are recommended for an effective supplemental lighting program. They provide maximum light intensity and trouble-free performance, and they are well-suited for nearly any kind of dairy housing unit.

Other, more efficient (more light per watt) lamps also can be used, but these lights may not be suitable for all types of dairy barns. Two of these include mercury-vapor lamps and high-pressure sodium lights. For a comparison of the differences between some of the various types of lights that may already exist on your dairy farm, see Table 2.

Regardless of whether light fixtures already on the farm are incandescent or fluorescent, the dairy farmer must consider whether those lamps will provide the needed intensity recommended for a successful lighting program, and whether existing light fixtures are properly positioned inside the barn for use in a supplemental lighting program.

Q. To be effective, how intense does the lighting need to be?

A. Light intensity is measured in lighting units called *footcandles*. Table 3 outlines some examples of the number of footcandles that would be equal to particular light situations or environments. As the number of footcandles increases, the intensity of light also increases.

In this study, the intensity of supplemental light ranged from a minimum of 20 footcandles to a

TABLE 2: Comparisons of various types of lights that may be found on a dairy farm

Type of Lamp	Size in watts	Avg. output in lumens	Approximate lumens per watt[1]	Avg. hours of life[2]
Standard incandescent	25	225	9	
	40	480	11	
	60	810	14	750
	100	1,600	16	to
	150	2,500	17	1,000
	200	3,500	18	
	300	5,490	18	
Standard fluorescent	15	660	34	
	20	1,000	40	
	40	3,200	66	18,000
	60	4,080	68	
	75	5,475	78	
Mercury vapor	75	2,800	40	
	100	3,800	40	
	175	7,500	40	24,000
	250	11,600	45	
	400	21,000	50	
	700	39,000	50	
Metal halide	175	12,000	65	
	400	34,000	80	18,000
	1,000	95,000	90	
High-pressure sodium	250	25,000	80	
	400	47,000	160	20,000
	1,000	130,000	110	

[1]Includes the power requirement for the ballast when appropriate.

[2]These hours vary, and you should check the specifications on the package. "Long-life" incandescent bulbs are available in the range of 3,500 hours, but they deliver 10 to 15 percent fewer lumens per watt.

SOURCE: Extension bulletin E-1273, *Energy Management for Dairy Operators*

maximum of 130 footcandles. Because barn lighting differs from farm to farm, the intensity of light that is needed will also vary. However, a minimum of 20 to 30 footcandles during the 16-hour period is recommended. Table 3 can be used to estimate the existing intensity, but a light meter, such as that used by a photographer, would be the most accurate method to measure existing light intensity.

Q. How many light fixtures will I need to install, and how should they be positioned to get the most effective use out of a supplemental lighting program?

A. In this study, satisfactory results were achieved when fixtures were placed at the rate of one for every four cows (about 6 to 8 feet apart), 7 to 10 feet above the cows' heads. Diagram 1 illustrates a sample placement of lamps in stanchion or tie-stall housing. Note that fixtures are placed perpendicular to stalls.

Q. If I have free-stall housing, can I still use a supplemental lighting program?

A. It is possible, although a formula for placement and number of lamps that should be installed does not appear to be as clearcut as that used for tie-stall or stanchion housing. Animal scientists at Oregon State University have used free-stall housing in photoperiod studies similar to this one. In one experiment, high-pressure sodium lamps using 400 watt bulbs at a rate of one per 21 cows were installed. Lamps were placed in a high-ceiling barn, 20 to 24 feet above the floor of 4-by-7-foot free-stall units. Each lamp provided an average light intensity of about 12.5 footcandles, and lamps were left on for 18 hours per day to accommodate milking and feeding schedules. Under these conditions, a per-herd increase in milk yield of approximately 7 percent was reached.

In another Oregon State University study, researchers installed smaller high-pressure sodium lamps (150 to 200 watts) at a rate of one for every six cows. These fixtures provided an average light intensity of 13.5 footcandles.

From several supplemental lighting trials done in free-stall housing, MSU studies have shown that six 8-foot fluorescent light fixtures per 50 free stalls, situated over the alley between two rows of stalls, is adequate to stimulate milk yield in dairy cattle. It is best, however, to place lights over the heads of cows in the areas where they spend the most time.

Q. How long will it take to have lamps installed in my barn?

A. Estimated time needed to install lamps may range from a minimum of 4 hours for a 20-cow herd to 32 hours for a 200-cow herd.

Q. Earlier in this bulletin, the use of an automatic time clock to turn lights on and off was mentioned. Is an automatic timer really necessary?

A. Though not absolutely mandatory, an automatic timer is recommended to ensure accurate, labor-free timing of the 16-hour period of supplemental lighting that cows will receive. Many farmers who use the supplemental lighting programs on their farms have found that it is easier—and more efficient—to install the timers and let them do the work, than to worry about manually turning on and off the lights at the beginning and end of each 16-hour lighting period.

Q. Does it matter when I turn the lights on and off during the day?

A. Many farmers using a supplemental lighting program prefer to have their time clocks set to turn the lights on a short time before the day's first milking and turn them off 16 hours later. This is purely a matter of convenience, however. You should schedule the 16-hour period to begin and end as it works out best on your farm.

Q. What about extending the supplemental lighting period beyond 16 hours? If 16 hours is good, won't 24 hours be even better for my herd? Or using a supplemental program year-round instead of just in the fall and winter months?

A. In this case, longer isn't necessarily better. A 16-hour period was found to be the optimal length of time for the fall and winter months, because during those months, natural daylength is at a minimum—9 to 12 hours per day. During the spring/summer months, the amount of natural daylength—up to 16 hours—is already considered a long day, and no further supplemental light is required.

TABLE 3: Comparisons of footcandle measurements with selected environments or activities

Light intensity in footcandles	Description of environment or activity
3-10	Intimate dining area
30	Reading printed material, hotel room
70	Bank lobby
100	Barbershop, reading any material written in pencil
500-1000	Store showcases
10,000	Outdoors on a clear day

SOURCE: *Primer of Lamps and Lighting*, 3rd Ed., by Willard Allphin.

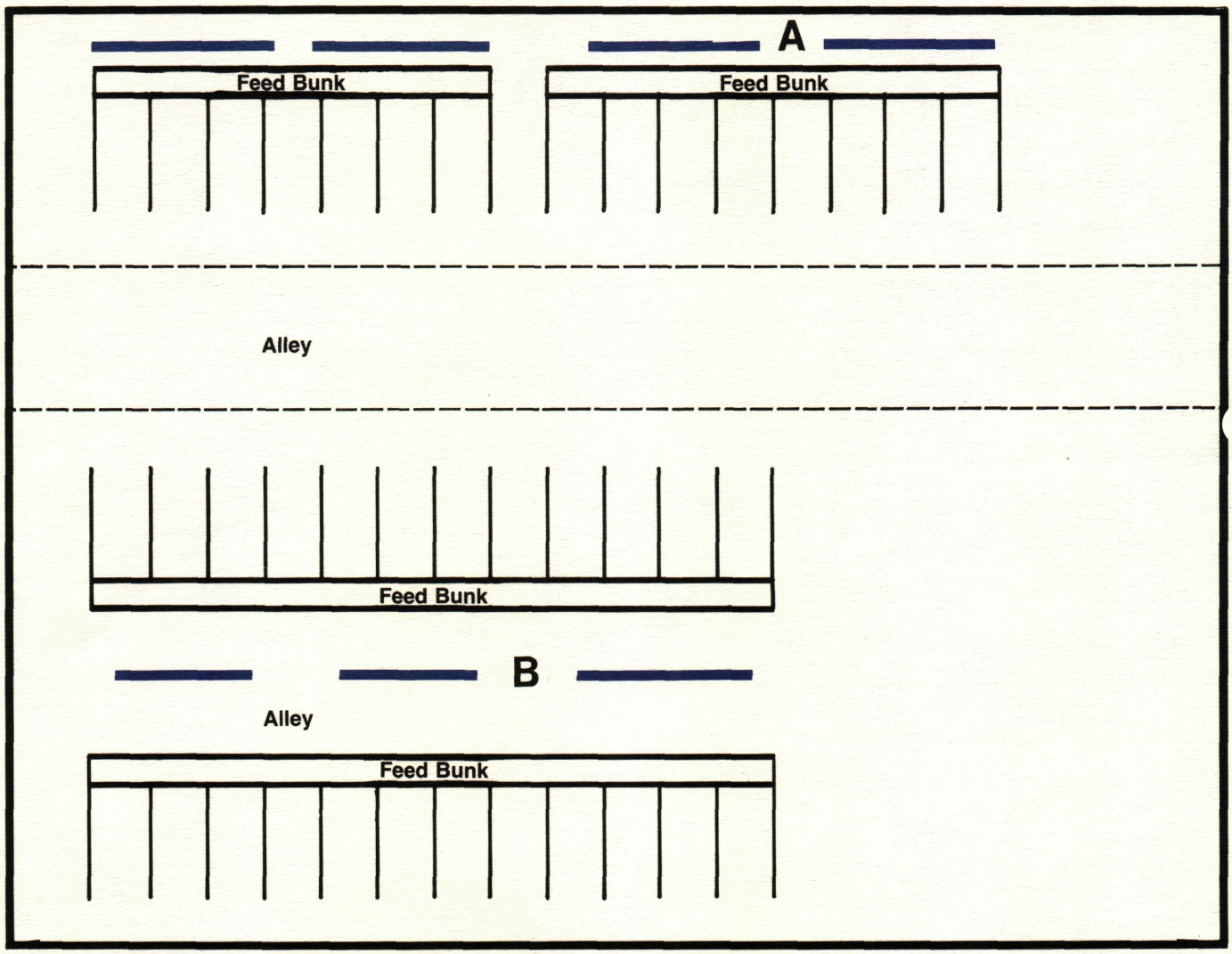
Q. Would there be any benefit from just supplementing the regular daylength for about 4 to 8 hours during the dark, and letting the natural sunlight, or daylength, take care of the rest?

A. It is possible to turn on your lights a few hours prior to dawn and turn them off after sunrise, or turn the lights on prior to dusk and extend the daylength into the night. Depending on the number of lamps you have, this could result in a significant savings in electricity. In any case, be sure that the total *continuous* duration of light that your cows receive is 16 hours.

Q. Would a supplemental lighting program really benefit my farm economically?

A. As discussed earlier in this bulletin, the farmer installing a completely new supplemental lighting program would reach the break-even point in two winters or less. The worksheet attached to this bulletin can help you determine what the actual costs would be for your farm.

DIAGRAM 1:
Sample floor plan of supplemental lighting program installation in stanchion or tie-stall barn.



= Individual tie stall or stanchion
= 8-ft fluorescent light fixture
A = Positioning of lights for stalls NOT facing head-to-head
B = Positioning of lights for stalls facing head-to-head

Worksheet to Aid Dairy Farmers in Estimating Potential Benefits from a Supplemental Lighting Program

Potential Income:

Total milk shipped per day: _____ lb/day × 0.08 = _____ lb/day LINE A

Percent butterfat test: (herd average)_____ percent − 0.16 percent = _____ percent* LINE B

(*If percent butterfat is below 3.5 percent, do LINES C, D and E.
If percent butterfat is above 3.5 percent, do LINES C and D, but insert a "zero" (0) in LINE E.)

Price received per 100 lb of milk: $_____/cwt
(When calculating this total, subtract $.16 for each 0.1 percent under 3.5 percent from LINE B, if applicable)

÷ 100 = $_____ lb of milk LINE C

LINE C × LINE A total _____ =

$_____ gross income per day − LINE E (if applicable) _____

= $_____ LINE D

Total current income from milk sales per day: $_____

− (milk shipped per day: _____ lb/day × LINE C) = _____

÷ number of milking cows: _____

= $_____ LINE E

Potential Expenses:

Average cost of feed per day (for all milking cows): $_____ × 0.06 = $_____ LINE F

Number of milking cows in herd: _____ ÷ 4 cows per fixture

× $.14 electricity cost = $_____ LINE G

To Determine Net Effect of Using Supplemental Lighting (Excluding Cost of New Lamps):

LINE D total $_____ − LINE F total $_____ − LINE G total $_____

= $_____ net income per day LINE H

Estimating Costs to Install Light Fixtures and Accessories

Stanchion/Tie-stall Barns:

Number of stanchions situated head-to-head but less than 20 feet apart, feed bunk to feed bunk (see area B on Diagram 1):

_____ cows ÷ 8 = _____ fixtures needed*

Number of stanchions in which cows are NOT facing head-to-head (see area A on Diagram 1)

_____ cows ÷ 4 = _____ fixtures needed*

Free-stall Barns:

- If using fluorescent lamps:

Number of free-stalls _____ × 1 fixture per 8 stalls = _____ fixtures needed*

OR

- If using high-pressure sodium or mercury vapor lamps (400 watts):

Number of free-stalls _____ × 1 fixture per 20 stalls = _____ fixtures needed*

(*Round to nearest whole number)

Number of barns housing milking cows: _____ × 1 timer = _____ timers needed

Total number of light fixtures needed _____ × $180 per fixture =

$_____ total dollars spent on lights LINE I

Total number of timers needed _____ × $85 per timer = $_____ total dollars spent on timers LINE J

Labor and miscellaneous supplies: _____ fixtures needed × $17* =

$_____ total dollars spent on labor/supplies LINE K

(*Based on $15 for 30 minutes of labor to install each fixture, plus $2 for miscellaneous supplies, such as wire, screws, etc.)

DETERMINING PAY-OFF TIME

Total costs of installing lighting system (sum of LINES I, J, and K): $_____

÷ LINE H (total net income) $_____

= _____ number of days for lighting program to pay off on your farm

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