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Economic feasibility of cooling dry cows across the United States

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ABSTRACT

Heat stress during the dry period reduces milk yield in the subsequent lactation of dairy cows. Our objectives were to quantify the economic losses due to heat stress if dry cows are not cooled and to evaluate the economic feasibility of dry cow cooling. We used weather data from the National Oceanic and Atmospheric Administration to calculate the number of heat stress days for each of the 50 US states. A heat stress day was declared when the daily average temperature-humidity index was ≥68. The number of dairy cows in each state in 2015 was obtained from the USDA-National Agricultural Statistics Service. We assumed that 15% of the cows were dry at any time, a 60-d dry period, and a calving interval of 400 d. Only cows in their second or greater parity (65%) benefitted from cooling during the dry period of the previous parity. Milk yield decreased by 5 kg in the subsequent lactation (340 d) if the cow experienced heat stress during the dry period based on a review of the literature. The default marginal value of milk minus feed cost was $0.33/kg of milk. The investment analysis included purchases of fans and soakers and use of water and electricity. Investment in a dry cow barn was considered separately. The average US dairy cow would experience 96 (26%) heat stress days during the year if not cooled and loses 447 kg of milk in the subsequent lactation if not cooled when dry. Annual losses would be $810 million if dry cows were not cooled ($87/cow per yr). For the top 3 milk-producing states (California, Wisconsin, New York), and Florida and Texas, the average milk losses in the subsequent lactation were 522, 349, 387, 1,197, and 904 kg, and reduced profit per cow per year would be $101, $68, $75, $233, and $176, respectively. The average benefit-cost ratio and payback periods of cooling dry cows in the United States were 3.15 and 0.27 yr (dry cow barn already present) and 1.45 and 5.68 yr (if investing in a dry cow barn) in the default scenario. To reach positive net present values, 6 d (barn is present) and 55 d (barn investment necessary) of heat stress annually were necessary (default assumptions). Other benefits of cooling, such as increased health and more productive offspring, were not considered. In conclusion, cooling of dry cows was profitable for 89% of the cows in the United States when building a new barn is required (under default assumptions) and very profitable when construction of a dry cow barn is not required (except for Alaska).
Key words: heat stress, temperature-humidity index, dry cow, economic feasibility

INTRODUCTION

Heat stress is a major factor affecting dairy cows across the United States. The effects of heat stress during the lactation on lactating cows have been extensively studied (e.g., West, 2003; Collier et al., 2006; De Rensis et al., 2015). St-Pierre et al. (2003) calculated that heat stress is responsible for annual losses of over $1 billion in the dairy industry in the United States if lactating cows are not sufficiently cooled, mainly due to the negative effects on milk production, DMI, reproduction, and culling. Heat stress is the costliest problem that dairy farmers face during the summer (Baumgard and Rhoads, 2012). However, these studies did not include the losses associated with dry cows that experienced heat stress. Although many farmers cool their lactating cows during periods of heat stress, cooling of dry cows is often ignored.

The long-term consequences of heat stress during the dry period were first studied by Collier et al. (1982) and Thatcher et al. (1984) who showed the effects on calf birth weight and the seasonality of birth weight in Holstein calves. Wolfenson et al. (1988) observed negative effects on calf weight and milk production. More recent work at the University of Florida has further demonstrated the benefits of dry cow cooling on improved calf performance and cow health in the next lactation. Heat stress during the dry period results in impaired mammary growth and consequently leads to decreased milk production in the subsequent lactation (Tao and Dahl, 2013). Cows cooled with soakers and fans during the entire dry period of 46 d had greater milk production of 5 to 7.5 kg/d in the subsequent lactation compared

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with those cows that were under shade only (do Amaral et al., 2009; Tao et al., 2011, 2012). When cows were cooled only during the last 2 wk before parturition, the increase in milk production in the subsequent lactation was 1.4 kg/d (Urdaz et al., 2006). In all these studies, all cows were cooled during the lactation.

Other effects of heat stress during the dry period are also reported, such as decreased fertility in cows (Wiersma and Armstrong, 1988), decreased immunity and fertility (do Amaral et al., 2011; Thompson and Dahl, 2012), and reduced birth weights and growth rates in calves born out of cows that experienced heat stress when dry (Collier et al., 1982; do Amaral et al., 2011; Tao et al., 2012).

Given the negative and long-term consequences of heat stress during the dry period, cooling dry cows may have economic benefits. Typical cooling of dry cows requires investments in soakers and fans. In addition, a dry cow barn may have to be built if dry cows are housed outside, as is common in, for example, Florida. These costs are not dependent on the length of time that heat stress would be experienced. Other costs to cool dry cows depend on the length of time during the year when dry cows would experience heat stress, which varies by geographic location across the United States.

Dhuyvetter et al. (2000) and St-Pierre et al. (2003) provided economic analyses of the cooling of lactating cows. The available economic analyses of cooling dry cows are limited. Adin et al. (2009) calculated that the total cost of cooling a dry cow in Israel was equivalent to the net income from 80 kg more milk. In that study, cows that were cooled during the dry period produced 190 kg more milk in the first 90 DIM versus cows that were not cooled when dry. However, Adin et al. (2009) did not account for the increase in DMI by cows that produced more milk, nor did they include other factors such as investment in cooling technology and number of heat stress days. We did not find other economic feasibility analyses of cooling dry cows.

Therefore, our first objective was to quantify the economic losses from lost milk production across the United States if all dry cows would not be cooled. Our second objective was to provide an economic feasibility analysis of investments in soakers and fans as well as cooling barns for dry cows across the United States.

MATERIALS AND METHODS

Weather Data

One measure of heat stress is a temperature-humidity index (**THI**) above a threshold (West, 2003; Collier et al., 2006). We quantified heat stress across the United States by calculating the average THI per calendar day for each of the 50 states. We used daily data provided by the National Oceanic and Atmospheric Administration for the years 2007 to 2013. The data set contained weather data including average daily temperature (°F) and dewpoint (°F). We averaged the data from all available weather stations within each state. Relative humidity (**RH**) was calculated as follows (NOAA, 2015):

$$\mathrm{RH} = \left\{\frac{\left[\left(173 - 0.1 \times \mathrm{T}\right) + \mathrm{dewpoint}\right]}{173 + \left(0.9 \times \mathrm{T}\right)}\right\}^{8},$$

where T = average daily temperature (°F). We calculated the THI according to the formula of Zimbelman et al. (2009):

$$\mathrm{THI} = \mathrm{T} - \left[0.55 - \left(0.55 \times \mathrm{RH}\right) \times \left(\mathrm{T} - 58\right)\right].$$

We declared a heat stress day when average daily THI $\geq$68 (Zimbelman et al., 2009). We calculated the number of heat stress days per state in each year and averaged those across the years.

Milk Production and Number of Dry Cows

We used data from USDA-NASS (2016) to obtain the total milk production and total number of dairy cows for each of the 50 states in the United States in 2015. We assumed that 15% of the total number of dairy cows were dry at any time during the year and the calving interval was 400 d. We also assumed that only cows in their second or greater parity (65%) benefitted from cooling during the dry period in the previous parity because we did not consider the benefits of cooling pregnant heifers during their later gestation period, although no evidence is present to indicate that they do not benefit. From this, we calculated the number of lactating cows that might benefit from cooling in the dry period.

Milk Losses

In Table 1, we summarized the results of 11 studies that documented the effects of heat stress during the dry period on milk loss in the subsequent lactation. Based on recent studies, we assumed a reduced milk production of 5 kg/d for 340 lactating days in her subsequent parity if the cow experienced heat stress during the dry period. Further, we assumed that the decrease in milk yield in a state was proportional to the number of heat stress days for that state. For example, 70% of the dry cows are under heat stress during the year if not cooled in Florida. Thus, without cooling, we assumed a loss in

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