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Multi-year evaluation of stocking rate and animal genotype on milk production per hectare within intensive pasture-based production systems

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ABSTRACT

The objective of this experiment was to evaluate the effect of stocking rate (SR) and animal genotype (BR) on milk production, body weight (BW), and body condition score (BCS) within intensive pasture-based systems. A total of 533 lactation records, from 246 elite genetic merit dairy cows were available for analysis; 68 Holstein-Friesian (HF) and 71 Jersey × Holstein-Friesian (JxHF) crossbred cows in each of 4 consecutive years (2013–2016, inclusive). Cows from each BR were randomly allocated to 1 of 3 whole-farm comparative SR treatments, low (LSR; 1,200 kg of BW/ha), medium (MSR; 1,400 kg of BW/ha), and high (HSR; 1,600 kg of BW/ha), and remained in the same SR treatments for the duration of the experiment. The effects of SR, BR, and their interaction on milk production/cow and per hectare, BW, BCS, and grazing characteristics were analyzed. Total pasture utilization per hectare consumed in the form of grazed pasture increased linearly as SR increased: least in LSR (10,237 kg of dry matter/ha), intermediate in MSR (11,016 kg of dry matter/ha), and greatest in HSR (11,809 kg of dry matter/ha). Milk and milk solids (MS) yield per hectare was greatest for HSR (15,942 and 1,354 kg, respectively), intermediate for MSR (14,191 and 1,220 kg, respectively), and least for LSR (13,186 and 1,139 kg, respectively) with similar trends evident for fat, protein, and lactose yield/ha. At higher SR (MSR and HSR), MS yield per kg of BW per ha was reduced (0.85 and 0.82 kg of MS/kg of BW, respectively) compared with LSR (0.93 kg of MS/kg of BW/ha). Holstein-Friesian cows achieved fewer grazing days per hectare (−37 d), and produced more milk (+561 kg/ha) but less fat plus protein (−57 kg/ha) compared with JxHF cows; the JxHF cows were lighter. At similar BW per hectare, JxHF cows produced more fat plus protein/ha during the grazing season at low (1,164 vs. 1,113 kg), medium (1,254 vs. 1,185 kg), and high (1,327 vs. 1,380 kg) SR. In addition, JxHF cows produced more fat plus protein per kg of BW/ha (0.90 kg) compared with HF cows (0.84 kg). The results highlight the superior productive efficiency of high genetic potential crossbred dairy cows within intensive pasture-based production systems.

Key words: stocking rate, crossbreeding, milk production, pasture-based

INTRODUCTION

Population growth, urbanization, and increasing disposable income are contributing to an increase in the demand for dairy products globally (Delgado, 2003; Robinson et al., 2015). This poses a challenge for agricultural production to use the available feed resources more efficiently, without adverse consequences for the natural environment. Consequently, the term sustainable intensification has been defined as the challenge of producing more food from the same resources, while reducing environmental effects of agricultural production (Pretty, 1997). In the context of pasture-based production systems, land is the limiting resource to productivity, and therefore, optimizing output per hectare through increasing pasture accumulation and utilization is pertinent to the sustainable intensification of grazing systems of animal production.

Stocking rate (**SR**), traditionally defined as the number of cows per unit area of land used during a defined period (i.e., cows/ha), is widely recognized as the primary lever to systematically improve pasture accumulation and utilization, and milk production per hectare while simultaneously reducing the requirement for external supplementary feed imports in grazing systems (Hoden et al., 1991; Macdonald et al., 2008a,b; McCarthy et al., 2016). Previous studies have also

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reported that cows/ha is a misleading measure of SR (Holmes et al., 2002), as it fails to account for variable pastureland productivity, nonpasture supplementation levels, and the diverse requirements of different dairy cow types commonly used within such systems. Consequently, McCarthy et al. (2011) expressed the effects of increasing SR on cow performance/100 kg of additional BW per ha as a more appropriate alternative measure of the SR effect within a predominantly pasture-fed dairy system. As SR increases, milk production per hectare increases linearly, whereas milk production per cow declines (McMeekan and Walshe, 1963; Macdonald et al., 2008a; McCarthy et al., 2011). In grazing terms, increasing SR increases grazing intensity and pasture utilization, resulting in higher pasture productivity and improved sward quality (Macdonald et al., 2008a; McCarthy et al., 2016).

Intensive grazing systems require a robust easy-care cow that has the capacity to efficiently convert pasture to high value fat plus protein [milk solids (**MS**); Berry, 2015]. Although Holstein-Friesian (**HF**) is the predominant breed within the Irish national dairy herd (Department of Agriculture, Food and the Marine, 2015), the inclusion of functional traits in the Irish total merit breeding index [Economic Breeding Index (**EBI**); ICBF, 2014], the introduction of a multi-component milk payment system rewarding fat and protein production and penalizing milk volume (Shalloo et al., 2007), and expanding herd sizes at farm level have contributed to an increasing interest in crossbreeding at farm level. The suitability of Jersey × Holstein-Friesian (**JxHF**) crossbred cows to intensive grazing systems is widely acknowledged in the literature by virtue of their small size and comparatively large intake potential (Mackle et al., 1996; Prendiville et al., 2009; Vance et al., 2013), JxHF cattle represent the near ideal cow for grazing systems and have displayed superior MS production and feed conversion efficiency compared with traditional HF counterparts in recent studies (Prendiville et al., 2009; Beecher et al., 2014; Coffey et al., 2017).

Although the results of these animal genotype (**BR**) comparison experiments are unequivocal, it is also widely acknowledged that comparing animals of differing BW (and associated maintenance requirements) on an individual animal basis confers a systemic advantage to the smaller animal (McCarthy et al., 2013; Dong et al., 2015). Notwithstanding the frequency of international BR comparison studies, it remains unclear if the superiorities reported for JxHF cows are consistently achieved across a wide array of intensive grazing management systems where SR may be more accurately defined in terms of BW per hectare and where feed inputs are consistently regulated. Consequently, the objective of the present experiment was to evaluate the interaction of SR and BR on milk production per hectare and associated effects of grazing characteristics, BW, and BCS within pasture-based milk production systems wherein SR is defined in terms of kilograms of BW per hectare and using high genetic merit spring-calving dairy cows of both BR groups combined with intensive grazing management practices over a 4-yr period.

MATERIALS AND METHODS

The experiment was undertaken at the Animal & Grassland Research and Innovation Center, Teagasc Moorepark, Ireland (50°7 N, 8°16 W), over a 4-yr period (2013–2016, inclusive). A total of 533 lactations from 246 spring-calving dairy cows were analyzed, with 139 cows used in each year of the experiment. It formed part of a larger experiment designed to examine the biological and economic effects of alternative SR and BR combinations. A more detailed description of the cows, treatments, and experimental design has been previously reported (Coffey et al., 2017).

Experimental Design, Treatments, and Cows

The experiment was a randomized block design with a 3 × 2 factorial arrangement of treatments. In each year, the 6 experimental treatments consisted of 3 whole-farm SR (1,200, 1,400, and 1,600 kg of BW/ha) and 2 BR (HF and JxHF). The SR (cows/ha) corresponded to 2.4, 2.9, and 3.3 cows/ha for LSR, MSR, and HSR for HF cows, respectively, and 2.5, 3.0, and 3.4 cows/ha for LSR, MSR, and HSR for JxHF cows, respectively. The average EBI, milk, fertility, calving, beef, maintenance, management, and health sub-indices of the HF cows were €205, 63, 103, 33, −12, 15, 2, and −1, respectively, and €198, 68, 89, 30, −24, 32, 3, and −1, respectively, for the JxHF cows. The average EBI of the cows of both BR during the experiment (ICBF, 2015) ranked them in the top 1% of the national herd during the same period.

Cows within each BR were randomly assigned pre-calving based on expected calving date, parity, and EBI to 1 of 3 SR treatments: low (**LSR**; 1,200 kg of BW/ha), medium (**MSR**; 1,400 kg of BW/ha), and high (**HSR**; 1,600 kg of BW/ha). The LSR treatment was designed to allow individual cows to achieve a high level of pasture allowance and milk production per cow, whereas the MSR and HSR treatments were designed to investigate the potential to increase pasture utilization and milk production per hectare through increasing SR and grazing intensity while reducing feed allowance per cow. The SR implemented in the MSR and HSR treat-