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An Evaluation of High Genetic Merit Cows Using Forage and Pasture Based Systems

Authors

Pat Dillon and Frank Buckley

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Teagasc,
Moorepark
Research Centre,
Fermoy.
Co. Cork

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Introduction

The rate of genetic improvement in Ireland up until the mid-80's was low (approx. 0.5% per year) compared to North America where genetic merit for milk production was increasing by 1.5% per year (Funk, 1993). Since 1985 the rate of genetic improvement increased markedly to about 1.5% per year in 1992 (Coffey, 1992). This high rate of genetic progress has mostly been achieved through the importation of North American and European genetics. The relative merit of these sires has been obtained from the performance of their progeny in systems of milk production which differ greatly from those operated in Ireland.

The term "high genetic index" (HGI) is used to describe a cow, which as a result of selection, is generally predisposed to produce significantly more milk than a cow of lower merit status. Studies from New Zealand have shown that cows of high "genetic index" at pasture, produce more milk (20 to 40%), consume more herbage (5 to 20%), were more efficient convertors of food into milk (10 to 15%) than lower merit cows (Holmes, 1988). However, these "high" genetic index cows would be considered "low" when compared to present-day genetics. Recent results from Langhill (Veerkamp *et al.*, 1994) have shown that increasing genetic index results in major increases in feed efficiency, reflecting increases in milk yield with cows fed indoors on silage/concentrate diets. There is little information available on the performance of present-day HGI dairy cows, on seasonal calving, grass-based systems of milk production.

Implication of increased cow genetic merit (CGI)

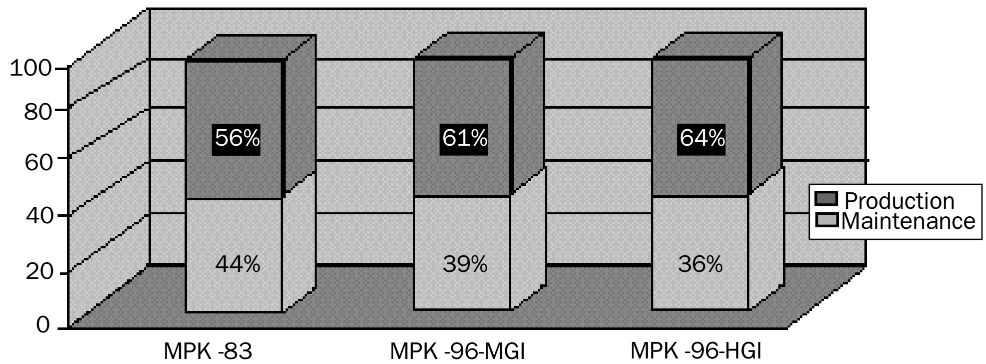
Table 1 shows how improved management and breeding has contributed to increased output per cow and per hectare since 1983 in controlled full lactation experiments at Moorepark. "Moorepark 1983" refers to the performance being achieved at the introduction of EU milk quotas in 1983. "Moorepark 1996 MGI" and "Moorepark 1996 HGI" refer to the performances being achieved at present with cows with present-day medium genetic index (MGI) and very high genetic index (HGI) in similar feeding systems. This has led to an increase of 50% and 28% in milk yield per cow and per hectare, respectively. It is not possible to differentiate precisely how much of this increase came from genetic improvement and how much came from management plus feeding. Figure 1 shows the effect of this increased performance on overall feed efficiency. With the Moorepark cow of 1983, 44% of its total feed requirement was required for maintenance, while with the HGI cows of 1996, only 36% of its feed requirement was required for maintenance. This has resulted in an increase in feed efficiency of 16%. There is no evidence that CGI has any influence on partial efficiency of ME use for milk production (Grainger et al., 1985). Therefore, the extra energy requirement for milk yield must come from increased intake and/or greater mobilisation of body reserves, especially in early lactation. Recent studies have shown (Veerkamp et al., 1994) that cows of HGI produce significantly higher milk yield than cows of lower genetic index (LGI) with only small differences in intake of energy. A breeding programme based solely on increased milk yield and angularity (or dairyness) without consideration of feed intake may result in an animal which depends on large mobilisation of body tissue in early lactation (negative energy balance) to support high milk yields. Such a breeding programme may not be suitable in seasonal spring-calving systems which depend to a large extent on grazed grass as a feed, due to the possibility of increases in metabolic disorders and reduced fertility performance.

Table 1. Evaluation of the Moorepark Milk Production Technology

		Moorepark 1983 Pre-quotas	Moorepark 1996 MGI•	Moorepark 1996 HGI•
Milk yield	**(kg/cow)**	**5076**	**6585**	**7640**
Stocking rate	**(cow/ha)**	**2.90**	**2.60**	**2.47**
Nitrogen	**(kg/ha)**	**380**	**380**	**380**
Grazed grass	**(t DM/cow)**	**3.30**	**3.69**	**3.88**
Silage	**(t. DM/cow)**	**1.40**	**1.56**	**1.65**
Conc.	**(t. DM/cow)**	**0.63**	**0.63**	**0.63**
Total intake	**(t. DM/cow)**	**5.3**	**5.9**	**6.2**

•MGI = Medium Genetic Index
•HGI = High Genetic Index

Figure 1: Effect of increased milk production on feed efficiency (relative ME requirements for maintenance and production)



Moorepark Comparison

In the autumn of 1994, two contrasting genetic groups of in-calf heifers were assembled at Moorepark. The experiment ran for a period of 3 years (1995 - 97) inclusive. The pedigree index of the two groups is shown in Table 2. The pedigree index of the HGI group were 13 kg of fat and 14 kg of protein higher than the MGI group. It should be noted that average RBI (95) for first lactation animals in 1995 nationally was 104 (IDRC).

Table 2. The pedigree index of the two genotypes being compared

Genotype	RBI 95	Milk (kg)	Fat (kg)	Protein (kg)	Fat (%)	Protein (%)
HGI	134	620	23	20.5	-0.02	0.00
MGI	117	120	10	7.1	+0.09	+0.05

Three different feeding systems were compared with each genotype. The Moorepark feeding system (System A) incorporates high stocking rate (2.54 cows/ha), high nitrogen input (400 kg N/ha) and a planned concentrate input of 500 kg/cow (Dillon *et al.*, 1995). System B had a similar stocking rate and nitrogen input to System A, but twice the level of concentrate. System C had a similar level of concentrate and nitrogen to System A but with unrestricted levels of high quality grass throughout the year To maintain system C, achieving second-cut silage was not a priority. The feeding systems were applied from mid-April to end of November. A total of 48 HGI and 48 MGI animals were used. Excess grass was harvested as wrapped baled silage to maintain grass quality. Grass was considered to be in excess when pre-grazing yields were >2000 kg DM/ha. In 1996, a total of 3.2 ha in system A, 3.8 ha in system B, and 4.8 ha in system C were harvested in this manner.

Performance in 1995

Tables 3 and 4 show the average performance of the two genotypes across the three feeding systems (adjusted for calving date) in 1995 and 1996. In 1995, when all animals were in their 1st lactation, the HGI heifers produced significantly more milk per cow (+945 kg) of a lower fat content (-0.31%) and slightly lower protein content (-0.09%). The yield of fat and protein was significantly higher for the HGI heifers. The grass-growing season of 1995 was very erratic with very poor growth rates in the August/September period due to the large moisture deficit. Concentrate supplementation therefore was much higher than planned. The actual concentrate feeding levels were 863, 1449 and 859 kg concentrates/cow for the feeding systems A, B, and C, respectively. There was no interaction between feeding system and CGI, i.e. both groups of heifers responded similarly to each feeding system. The average response to concentrate feeding was 0.80 kg milk/kg of extra concentrate fed in feeding system B.

Table 3. Effect of cow genetic index on milk production (1995)

	MGI	HGI	Difference (H-M)
	Total	Total	Total
Milk (kg/cow)	5,496	6,441	+945
(Gallons/cow)	1,174	1,376	+202
Fat %	4.06	3.75	-0.31
Protein %	3.53	3.44	-0.09
Fat (kg)	222	241	+19
Protein (kg)	193	222	+29
Lactation length (days)	296	303	+7

Performance in 1996

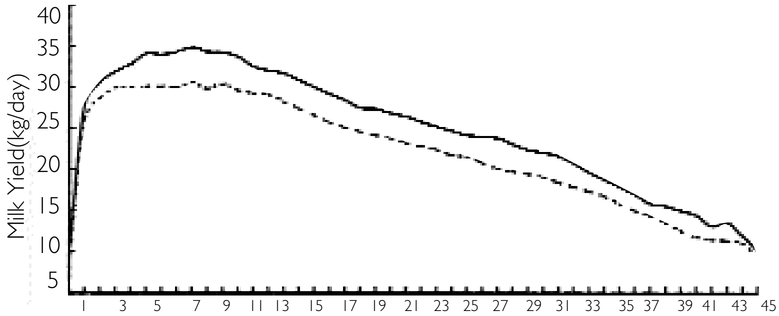
Table 4 shows the milk production for both genotypes (averaged across the three feeding systems). In Figure 2, the milk production profile for both genotypes is shown.

Table 4. Effect of cow genetic index on milk production (1996)

	MGI	HGI	Difference (H-M)
	Total	Total	Total
Milk (kg/cow)	6,860	7,764	+904
(Gallons/cow)	1,465	1,659	+194
Fat %	4.02	3.89	-0.13
Protein %	3.43	3.41	-0.02
Fat (kg)	274	302	+28
Protein (kg)	235	264	+29
Lactation length (days)	305	303	-2

The HGI cows produced significantly higher yields of milk (+904 kg), fat (28 kg) and protein (29 kg) of slightly lower fat content (-0.13) and with similar protein content. The average daily milk production for the MGI and HGI cows was 22.5 kg (4.8 gals) and 25.6 kg (5.5 gals) per cow over the lactation. Peak milk production was obtained in early May at 35 kg/cow/day (7.5 gals) and 31 kg/cow/day (6.6 gals) for the HGI and MGI cows, respectively. Lactation lengths were similar for both genotypes.

Figure 2 : Effect of cow genetic index on mean milk yield by week of lactation



Tables 5, 6 and 7 show the milk production (adjusted for calving date) for both genotypes on each feeding system. The concentrate feeding levels were 695, 1340 and 695 kg concentrate/cow for feeding systems A, B and C, respectively, over the entire lactation in 1996. Concentrate supplementation exceeded the target level in 1996 due to delayed turnout resulting from poor grass growth rates. Cows were turned out to pasture by day on April 1, and by day and night on April 10. There was no interaction between CGI and feeding system, although the difference in fat and protein yield between genotype was greatest in feeding system B (+64 kg). The average response was 1.12 and 0.92 kg milk/kg extra concentrate fed for the HGI and MGI cows, respectively, of solids-corrected milk. The best responses were obtained in the autumn period and the lowest responses were recorded in early spring. The milk yield response to feeding system C was 190 kg (41 gals) of solids-corrected milk over the total lactation. The largest responses were again obtained in the autumn when supplemented with high quality grass silage while the Moorepark feeding system were on grass-only. Milk protein content was increased with feeding system C when compared to system A.

Table 5 Effect of cow genetic index on milk production - Feeding System A

	MGI	HGI	Difference
	Total	Total	(H-M)
Milk (kg/cow)	6,576	7,632	+1,056
(Gallons/cow)	1,405	1,630	+225
Fat %	4.11	3.76	-0.35
Protein %	3.39	3.37	-0.02
Fat (kg)	266	286	+20
Protein (kg)	222	257	+35
Lactation length (days)	302	300	-2

Table 6. Effect of cow genetic index on milk production - Feeding System B

	MGI	HGI	Difference
	Total	Total	(H-M)
Milk (kg/cow)	7,221	8,142	+921
(Gallons/cow)	1,543	1,739	+196
Fat %	3.96	3.97	+0.01
Protein %	3.45	3.41	-0.04
Fat (kg)	285	321	+36
Protein (kg)	249	277	+28
Lactation length (days)	309	307	-2

Table 7. Effect of cow genetic index on milk production - Feeding System C

	MGI	HGI	Difference
	Total	Total	Total
Milk (kg/cow)	6,786	7,518	+732
(Gallons/cow)	1,450	1,606	+156
Fat %	4.03	3.96	+0.07
Protein %	3.45	3.45	-0.00
Fat (kg)	272	298	+26
Protein (kg)	233	259	+26
Lactation length (days)	305	303	-2

Grazing Management and Intake

Table 8 shows the intake estimates taken in both 1995 and 1996. Individual animal intake was measured on 4 occasions during lactation in 1995 (May to November) using the n-alkane technique of Mayes *et al*. (1986), as modified by Dillon and Stakelum (1989). Over the four intake measurement periods, concentrate supplementation levels of feeding systems A, B and C averaged 1.0, 3.5 and 1.0 kg/day, respectively. During the 3 measurement periods in 1996 (June to September), feeding systems A and C were on grass only while feeding system B was supplemented with 3.0 kg of concentrates daily. For both years, the HGI group had higher intakes (5% in 1995 and 8% in 1996). In 1996, the daily allowance of herbage (>4 cm) to achieve these intakes were 24, 21 and 27 (kg DM/cow) for feeding systems A, B, and C, respectively. Supplementation with concentrates at pasture significantly increased total dry matter intake (TDMI) in both years with small reductions in grass dry matter intakes (GDMI). Previous studies (with lower milk producing cows) have shown that when cows are supplemented with concentrates at pasture, large substitution rates can occur.

Previous results from Moorepark (Stakelum *et al*., 1988) suggest that at daily intakes of 10, 12, 14, 16 and 17 kg of grass dry matter/cow, substitution rates of 0.20, 0.32, 0.44, 0.55 and 0.62 kg/kg of concentrate, respectively, will result. The reduction in grass intake per kg of concentrate offered in study in 1996 was 0.2. The consequence of this is the very good milk yield response to the concentrate which was achieved. The increase in intake with feeding system C averaged 0.5 kg/day when compared to feeding system A.

During the dry period of 1996, individual intakes were measured on 20 HGI and 20 MGI cows. The genotypes were balanced on expected calving date and received high quality silage (75 DMD) *ad-lib*. The HGI cows had significantly ($P<0.01$) higher DM intakes at 13.2 and 12.1 kg/cow/day for the HGI and MGI cows, respectively.

Table 8. Effect of cow genetic index and feeding system on grass (GDMI) and total (TDMI) intake (kg DM/cow/day)

	Feeding System					
	A		B		C	
	HGI	MGI	HGI	MGI	HGI	MGI
GDMI[1]	14.2	13.4	13.9	13.5	15.1	14.1
TDMI[1]	15.1	14.3	16.9	16.6	16.0	15.0
GDMI[2]	20.3	18.6	19.6	18.3	20.7	19.2
TDMI[2]	20.3	18.6	22.2	20.9	20.7	19.2

[1] = 1st lactation
[2] = 2nd lactation

Liveweight and condition score

Table 9 shows the liveweight at critical stages of lactation for both genotypes, while Figure 3 shows the effect of genotypes by week of lactation. Over the total lactation, the HGI cows gained less liveweight during the lactation (27 kg in 1995; 59 kg in 1996) compared to the MGI (42 kg in 1995; 86 kg in 1996). This was as a result of either losing more liveweight in early lactation and/or gaining lower liveweight in the second half of lactation. The opposite was the situation during the dry period when the average liveweight gain was 1.20 and 0.90 for the HGI and MGI cows, respectively. This high level of liveweight gain during the dry period was achieved on *ad-libitum* high quality silage (75 DMD). Feeding system had no effect on liveweight at any stage of lactation.

Table 9. Effect of cow genetic index on liveweight

	1st lactation (1995)		2nd lactation (1996)	
	HGI	MGI	HGI	MGI
Pre-calving	592	585	650	634
Week 1 of lactation	522	518	572	563
Week 9 of lactation	491	490	536	538
End of lactation	549	560	631	649
Pre-calving	650	634	707	701

Figure 3 : Effect of cow genetic index on mean liveweight by week of lactation (1996)

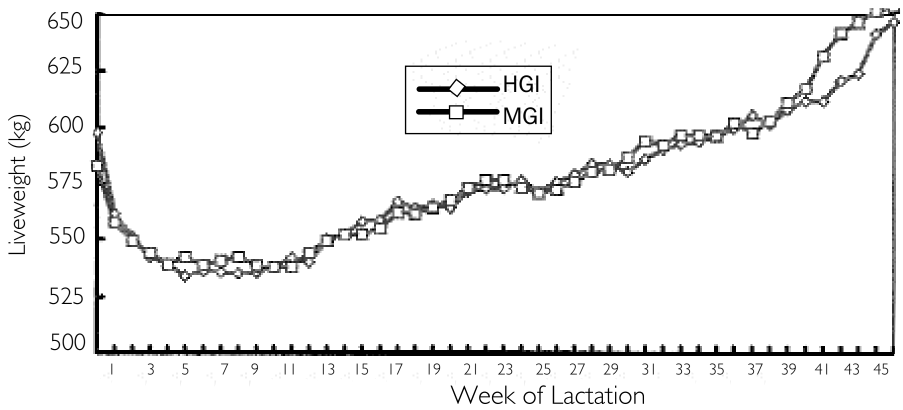


Table 10 shows the condition score at similar stages of lactation to that of liveweight in Table 9. Condition score changes follow liveweight changes during lactation. The condition score of the HGI cows was lower at all stages of lactation when compared to the MGI cows, while again feeding system had no effect.

Table 10. Effect of cow genetic index on condition score

	1st lactation (1995)		2nd lactation (1996)	
	HGI	**MGI**	**HGI**	**MGI**
Pre-calving	**2.79**	**3.25**	**3.04**	**3.38**
Week 9 of lactation	**2.35**	**2.77**	**2.44**	**2.92**
End of lactation	**2.52**	**2.97**	**2.75**	**3.35**
Pre-calving	**3.04**	**3.38**	**3.11**	**3.65**

Table 11 shows that the effect of cow genetic index on liveweight and condition score changes in early lactation. The HGI cows had greater livewieght and body condition score reduction in the first four weeks of lactation. Both genotype had similar changes from week 4 to 20 of lactation.

Table 11. The effect of cow genetic index on live-weight and condition score changes in early lactation over the two year

	Cow genetic index	
	HGI	MGI
Weight change		
Week 1-4 (kg/cow/day)	-0.80	-0.65
Week 4-8 (kg/cow/day)	-0.33	-0.26
Week 8-12 (kg/cow/day)	0.06	0.06
Week 12-16 (kg/cow/day)	0.18	0.18
Week 16-20 (kg/cow/day)	0.29	0.25
Condition Score		
Week 1-4	-0.14	-0.09
Week 4-8	-0.12	-0.07
Week 8-12	-0.03	-0.04
Week 12-16	0.00	-0.01
Week 16-20	0.03	0.01

Fertility performance

Table 12 shows the effect of cow genetic index on fertility performance for 1996 and 1997. The breeding seasons were confined to 13 weeks in both years. There was no effect of cow genetic index on submission rate, calving-to-service-interval, or calving-to-conception-interval. However, the HGI cows had a greater number of services per conception, lower pregnancy rates to 1st and 2nd service with subsequently higher proportion of cows not in calf. There was no indication that feeding system had any effect on any of the fertility parameters measured.

Table 12. Effect of cow genetic index on fertility performance

		HGI		MGI	
		1996	1997	1996	1997
Calving to 1st service interval	(days)	71	69	73	68
Calving to conception interval	(days)	87	85	92	85
Cows served in 1st 3 weeks	(%)	88	88	85	100
Services per cow		2.02	2.14	1.79	1.79
Pregnancy rate :	1st service	38	44	54	52
	2nd service	43	30	59	57
Not in calf	(%)	21	25	6	6

Discussion

1. There was no indication of an interaction between CGI and the feeding system evaluated in this study. However, there was an indication that the response to concentrates was higher with the HGI cows in 1996 (1.12 and 0.9 kg milk/kg of extra concentrate fed with the HGI and MGI cows, respectively). It is also important to emphasise the narrow range of the genotypes used in this study. The two years results also indicate that the difference in milk production between the two genotypes is very similar to that which can be predicted from the pedigree index.

2. There is a clear indication in this study that selection of cows for higher milk production leads to higher feed intake as a consequence of the genetic correlation between these traits. To accommodate a cow with an RBI (95) of 135, as compared to that of 100, it is estimated that stocking rate would have to be reduced by between 15 and 20%, if most of the extra milk production is to be obtained from grazed grass and silage. With reduced stocking rate in place then, it will depend on grazing management skills of the farmers to be able to consistently maintain a sward of high quality. Cows, regardless of their genetic merit, require good management practices to be adhered to if they are to perform to their potential. This is especially so as the herds CGI increases.

3. The milk yield response to feeding extra concentrates at pasture was much higher than that reported previously with lower milk-producing cows. Hoden *et al*. (1991) reported higher milk yield responses from higher-producing cows. The higher milk yield responses are supported with the lower substitution rates of concentrates for grass and no effect of feeding system on liveweight change. The milk yield response to allocation of extra grass (system C) was small (190 kg), however milk protein content was increased. These results are supported with the small increase in GDMI achieved. However, feeding system A (which is the Control) was managed on a daily basis to provide sufficient high quality grass with a post-grazing height of 5 to 6 cm.

4. The reduced fertility performance of the HGI cows is of concern and will require further investigation. However, evidence is accumulating to suggest that milk production will mainly reduce reproductive performance when the intake of energy is insufficient to meet current milk output and this results in prolonged negative energy balance (NEB) in early lactation. The severity and duration of NEB may vary, depending on body condition score at calving, production level, ration formulation and environmental factors. Studies to more precisely define the effect of increasing milk yield in early lactation on reproductive performance, especially in Holsteins require to be established for Ireland. Oestrus detection rates and pregnancy rates for American Holsteins of less than 50% are accepted widely in the USA (Macmillan *et al.*, 1996).

Conclusions

The objective of this study was to evaluate the performance of HGI and MGI cows on three grass based feeding systems.

The results clearly show that cows of HGI produce higher yields of milk and milk constituents. There was no significant CGI x feeding system interaction observed for any of the measurements taken, indicating that HGI dairy cows do not respond differently to feeding system when compared to MGI cows (across the range of diets examined). It is also evident that HGI cows have higher grass DM intake and total DM intake.

The study also indicates that HGI cows have a higher rate of liveweight loss in the post-calving period, and that HGI cows have a lower live-weight gain during lactation, suggesting greater body tissue mobilisation. They also exhibit higher rates of gain during the dry period. The HGI cows clearly maintain a lower condition score at all stages of lactation suggesting a high correlation between selection for CGI and this trait.

Feeding system had a significant effect on yield of milk and milk constituents, DM intake, and had no effect on milk composition. Feeding system had no effect on live-weight, condition score, live-weight change, and condition score change. In the present study, milk yield response to additional concentrate fed was much larger than that reported previously. Both genotypes in the present study are of higher genetic index than those in previous studies.

The present study may suggest that increasing CGI has a detrimental effect on fertility performance, although further research is required in this area.

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