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Economic and Genetic Aspects of Using Sexed Semen in Traditional and Genomic Evaluation of Iranian Holstein Dairy Cattle: A Simulation Study

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ABSTRACT

In recent years, sexed semen has been commercially available. Due to its lower fertility and higher price compared to conventional semen, economic evaluation should be undertaken before recommending the technology to dairy producers in each country. The objectives of the present study were to evaluate the advantages and disadvantages of the sexed semen usage at farm level in economic conditions of Iran based on total net present value (TNPV) and to estimate the impact of sexed semen on the rate of genetic improvement in dairy cattle population with and without using genomic information. Three relative conception rates (RCR) of sexed semen compared to the conventional semen were assumed i.e. 0.80, 0.75, and 0.70. Visual basic 6 and Excel software were used for calculations. The results showed that greater numbers of sexed semen services in heifers resulted in higher *TNPV* for all assumed *RCR*s, but for cows in parities 1 and 2, use of two sexed semen services for *RCR*, 0.80 and 0.75 resulted in the highest *TNPV*; while, for *RCR*= 0.70, the results indicated that using sexed semen was not economical. By using traditional evaluation, genomic evaluation with 3k chip, and genomic evaluation with 50k chip, the additional genetic gains in 305-day milk yield were, respectively, approximately 25, 34, and 38% higher than the current annual genetic progress for this trait in Iran (that is, about 53 kg per year).

Keywords: Economic evaluation, Genetic gain, Milk yield, Net present value.

INTRODUCTION

Dairy farmers use sexed semen to increase the proportion of female calves. The reliable and repeatable method to produce sexed semen is a flow cytometry procedure. Based on large sample sizes, 49% of calves born are female calves, while by using sexed semen, about 90% of calves born will be female calves (Norman *et al*., 2010), thus, with sexed semen, not all female calves are necessarily kept as replacement heifers, and farmers could select genetically superior heifers as herd replacements.

About 10-15% of spermatozoa entering the sorting machine are recovered as viable spermatozoa which results in lower fertility of sexed semen relative to conventional semen (De Vries, 2010). Relative conception rate (RCR) of sexed semen compared to that of conventional semen is approximately 70-80% (Seidel, 2003). Additionally, a dose of sexed semen is, on the average, more expensive than conventional semen, with the difference depending on the sires. Due to the lower fertility and the higher price of sexed semen compared to those of conventional semen, reproductive and economic parameters should be considered in each

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country before recommending sexed semen to commercial dairy producers.

Van Vleck (1981) predicted that the rate of genetic progress in dairy cattle could increase by 15% if sexed semen would be widely available. Baker *et al.* (1990) concluded that using sexed semen in elite cows and sires would have a very minor effect on the rate of genetic progress, but it would have a great impact on the economic efficiency of dairy farms. In recent years, genomic prediction has revolutionized livestock genetic evaluation system. This technology predicts breeding value of animals for each trait using genome-wide dense marker maps (Meuwissen *et al.*, 2001). Using sexed semen along with genetic evaluation could result in more genetic progress in dairy cattle.

There is no milk quota system in Iran and most dairy companies pay for the amount of milk, and little attention is paid to the percent of fat or protein. While improving production per cow or expansion of herds are both desirable, milk yield is the most important trait for dairy producers, and it is the appropriate trait to study the impact of sexed semen usage for genetic improvement in Iran.

Additional costs and revenues associated with sexed semen must be taken into account in economic evaluation of sexed semen. Additional revenue is the extra value due to production of more female calves; additional costs are the decrease of conception rate and the higher price of sexed semen compared to that of conventional semen.

The objectives of this study were to evaluate the use of sexed semen in Iran's economic conditions and the impact of economically optimum use of sexed semen on the additional genetic gain in 305- day milk yield with and without genomic information based on total net present value (TNPV). A sensitivity analysis was carried out to study the effect of altering marketing circumstances on the results of economic evaluation of sexed semen.

MATERIALS AND METHODS

Economic Evaluation

Economic evaluation of utilizing sexed semen was performed by using reproductive and economic parameters. These parameters were *RCR* in each insemination, the price of sexed and conventional semen, the price of female and male calves, the average maintenance costs of non-pregnant heifers and cows, salvage values of culled heifers and cows, and annual discount rate.

Dejarnette *et al.* (2009) pointed out that the fertility of sexed semen was approximately 80% of that achieved with conventional semen. Norman *et al.* (2010) reported that the conception rate (CR) with sexed semen was in the range of 69-83% of that with conventional semen. In the present study, *RCR* was assumed to be 0.80, 0.75, and 0.70, and *CR* of conventional semen for each insemination service was obtained from data of three large commercial Holstein farms in Iran (in Qom, Esfahan and Yasuj) from March 2009 to March 2011. *CR*s for different insemination services are summarized in Table 1. The female: male ratio of calves produced by conventional semen was set at 48:52 (Norman *et al.*, 2010). This ratio for sexed semen was

Table 1. Pregnancy rate (PR) of heifers and cows in parities 1 and 2.[a]

	Service Number			
	1	2	3	>= 4
Heifer	65.0	64.6	63.3	61.9
Parities 1	45.5	44.0	42.8	42.7
Parities 2	43.5	43.0	41.1	40.6

[a] Records were collected from approximately 8400 heifers, 6950 cows in parities 1 and 550 cows in parities 2 in Iran.

assumed to be 90:10 (Seidel, 2003; De Vries, 2010). Annual discount rate was set to 12%.

Economic parameters used in this study were based on Iran's market. The average prices of about 10 large commercial Holstein farms were used. The average values for female and male calves at birth were set as US$835 and US$381, respectively. Maintenance costs per day for non-pregnant heifers and non-pregnant cows in parities 1 and parities 2 were US$2.16, US$2.63 and US$2.90, respectively. The average prices of heifers, cows in parities 1 and 2 were assumed as US$3,339, US$2,765 and US$2192, respectively. The prices of culling per kg of weight for heifers and cows were set as US$3.1 and US$2.5, respectively. The average prices of sexed and conventional semen were set as US$47.7 and US$19.1 per straw, respectively.

Expected *TNPV* was calculated using following formula (Cabrera, 2009):

$$TNPV = \left(\sum_{s=1}^{n}(\delta_s)(NPV_s)\right) + (\delta_n)(HC - HR)(1 - PP_n) \quad (1)$$

Where, δ is discount rate, *HC* is the received heifer or Cow cull value (salvage value)= Expected weight of heifer or cow at the time of culling × The culling price per kg of weight, *HR* is the value of a cow or heifer if she was not culled and PP_n is the proportion of pregnant heifers or cows after final service, and *n* is the final service.

The *NPV* after each service is (Cabrera, 2009):

$$NPV_s = CR_s^{'}(CV) - (1 - PP_s)(MC) - (1 - PP_{s-1})(IC) \quad (2)$$

Where, *CR'* is the conception rate achieved in service s, *CV* is the Calf value= (Bull calf probability×Bull calf value) + (Female calf probability×Female calf value), *MC* is the non-pregnant heifer or cow maintenance cost and *IC* is the insemination cost.

Conditional probabilities were used to determine the *CR* achieved (CR') and the proportion of pregnant cows or heifers (*PP*) in each service and were calculated using the following formula (Cabrera, 2009):

$$PP_1 = CR_1^{'} = CR_1 \quad (3)$$

$PP_s = PP_{s-1} + (1 - PP_{s-1})(CR_s)$ for s=2 to final service (4)

$CR_s^{'} = PP_s - PP_{s-1}$ for s=2 to final service (5)

The final insemination service for each *RCR* and each type of semen was the service in which 95% cumulative conception rate was achieved. Visual basic 6 and Excel software were used for the above calculations and performing the comparisons.

For each *RCR*, some schemes were assumed. In the first scheme, all insemination services were carried out with conventional semen. In second scheme, only the first insemination was assumed to be done with sexed semen, and in the other schemes, substitution of conventional semen with sexed semen was done until the final insemination service. In the final scheme, all services were done with sexed semen. The commercially optimum use of sexed semen for each *RCR* was the scheme in which the highest *TNPV* was achieved.

Sensitivity Analysis

To study the effect of altering marketing circumstances on the result of economic evaluation of sexed semen, a sensitivity analysis was carried out. The most effective economic parameters on the results of the economic evaluation of using sexed semen are the difference between sexed and conventional semen price and the difference between female and male calf price. The sensitivity analysis was carried out altering these two parameters while other parameters were constant. For calculation of additional profit per heifer or cow due to using sexed semen in different services, *TNPV* of the scheme in which all services were done with conventional semen was subtracted from *TNPV* of the other schemes.

The difference between female and male calf price was assumed to be US$100, US$200, US$300 and US$400 and the difference between sexed and conventional semen price was assumed to be US$15 and US$20.

Genetic Gain Calculation

The additional genetic gain in milk yield resulting from the economically optimum use of sexed semen was calculated. For this purpose, true breeding values (TBVs) and estimated breeding values (EBVs) of a herd with 50,000 heifers, 41,500 cows in parities 1 and 32,785 cows in parities 2 were simulated in Visual basic 6; the *CR* of the conventional semen for each service for heifers and cows in parities 1 and 2 was according to *CR* shown in Table 1.

The traditional evaluation (TE), genomic evaluation with 50 k chip (GE50k), and genomic evaluation with 3 k chip (GE3k) methods were considered for genetic evaluation. The reliability of *EBVs* (squared correlation of TBVs and EBVs) at birth was assumed to be 0.25 for *TE*. It was assumed that GE50k led to about 0.32 additional reliability for milk yield (VanRaden and Tooker, 2009) and GE3 k caused about 0.23 additional reliability for this trait in comparison with *TE* (VanRaden *et al.*, 2010). Therefore, the reliabilities of Breeding Value (BV) estimations in *TE*, GE3k and GE50k were assumed to be 0.25, 0.48 and 0.57, respectively.

Selection of Female Calves

If all services are undertaken with conventional semen there would be 50,000*0.95*0.48=22,800 female calves born from heifers, $41,500\times0.95\times0.48=18,924$ from cows in parities 1 and $32,785\times0.95\times0.48\approx 14,950$ from cows in parities 2, by assuming a cumulative conception rate of 95% and female: male ratio of 48:52 in conventional semen services. *EBVs* for calves were the mean of *EBVs* of their parents. It was assumed that there would be no selection on female calves in the scheme with conventional semen in all services; therefore, in the other schemes, 22,800 female calves would be born from heifers, 18,924 from cows in parities 1 and 14,950 from cows in parities 2 were selected. For example, in the scheme using sexed semen in all services, there would be about $50,000\times0.95\times0.9= 42,750$ female calves from heifers, by assuming a cumulative conception rate of 95% and female: male ratio of 90:10 in sexed semen services; 22,800 of these 42,750 female calves would be selected in this scheme. Standard deviation of milk yield was assumed to be 554 kg (Sahebhonar, 2008).

For each evaluation method and *RCR*, 0.80 and 0.75, the difference between average *TBVs* of the selected female calves and average *TBVs* of parents (genetic gain) was calculated for heifers, parities 1, and parities 2 cows, separately.

RESULTS

Economic Evaluations

The results indicated that the use of sexed semen for heifers is economically justified in all insemination services and all *RCRs* in Iran's current economic conditions. *TNPV* for each *RCR* and each number of sexed semen services for heifers are shown in Table 2. These results clearly show that, for heifers, greater numbers of services with sexed semen resulted in higher *TNPV*. Increasing the number of sexed semen services from 0 to 1 had the highest effect on *TNPV*. For example, for *RCR= 0.80*, *TNPV* increased about US$50 when the number of sexed semen services increased from 0 to 1, while the increase of *TNPV* was only US$1 when the number of sexed semen services increased from 4 to 5. Moreover, *TNPV* for each number of sexed semen services decreased when *RCR* decreased.

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Table 2. Total Net Present Value (TNPV) for each *RPR* and each number of sexed semen services for heifers (US $).

	Relative pregnancy rate of sexed semen compared to conventional semen (RPR)		
Service Number	0.80	0.75	0.70
0	383.57	383.57	383.57
1	433.74	421.99	410.24
2	455.78	439.56	422.57
3	465.97	451.09	431.80
4	473.73	455.38	435.12
5	474.39	457.03	439.94

The results indicated that for the cows in parities 1 and 2, for *RCR* equal to or more than 0.75, up to two services with sexed semen was economical, and for *RCR* equal to or lower than 0.70, using sexed semen was not economically justified. *TNPV* for each *RCR* and each number of sexed semen services for the cows in parities 1 and 2 are shown in Table 3. Using sexed semen up to two services in cows in parities 1 resulted in approximately US$21 and US$10 increase in profit per cow for *RCR*, 0.80 and 0.75, respectively. For the cows in parities 2, when two sexed semen services were done, the increased profits per cow were US$17 and US$9 for *RCR* of 0.80 and 0.75, respectively.

Sensitivity Analysis

The results of the sensitivity analysis are shown in Tables 4-5. The results showed that when the difference between sexed and conventional semen price was US$15-20 and the difference between female and male calf price was US$200-400, using sexed semen for all services was profitable for heifers.

For cows in parities 1, using sexed semen for all services was profitable in two situations. First, when the difference between sexed and conventional semen price was US$20 and the difference between

Table 3. Total Net Present Value (TNPV) for each RCR and each number of sexed semen services for cows in parity 1 and 2 (US $).

	Relative conception rate of sexed semen compared to conventional semen (RCR)		
Service Number	0.80	0.75	0.70
		Parity 1	
0	349.70	349.70	349.70
1	365.87	357.50	347.13
2	370.79	359.27	327.14
3	363.42	333.94	302.87
4	352.57	315.33	275.13
5	338.59	292.99	242.58
6	321.60	266.45	203.97
		Parity 2	
0	311.63	311.63	311.63
1	325.81	318.70	308.70
2	328.55	320.46	304.50
3	323.24	309.00	273.84
4	319.16	284.29	237.81
5	307.89	254.31	194.59
6	284.61	218.29	142.30

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Table 4. Additional profit per heifer for various differences between sexed and conventional semen and between female and male calf price (US $).

The difference between sexed and conventional semen price	The difference between female and male calf price	Relative conception rate of sexed semen compared to conventional semen (RCR)	Additional profit per heifer				
			Number of sexed semen services				
			1	2	3	4	5
20	100	0.80	-12.9	-20.6	-24.3	-25.2	-25.5
20	100	0.75	-18.7	-29.9	-32.7	-35.6	-36.7
20	200	0.80	8.6	11.1	12.1	15.6	15.6
20	200	0.75	1.5	1.7	2.4	2.5	2.7
20	300	0.80	30.2	42.8	48.6	54.3	54.7
20	300	0.75	21.6	30.8	38.2	40.4	41.2
20	400	0.80	51.7	74.5	85.1	93.1	93.8
20	400	0.75	41.8	61.1	73.6	78.4	80.2
15	100	0.80	-8.0	-13.0	-16.0	-14.0	-14.0
15	100	0.75	-14.0	-22.4	-23.9	-26.2	-27.1
15	200	0.80	13.6	18.4	24.5	24.6	24.7
15	200	0.75	6.4	7.9	11.5	11.8	11.9
15	300	0.80	35.1	50.1	57.1	63.3	63.7
15	300	0.75	26.6	38.2	46.9	49.8	50.9
15	400	0.80	56.6	81.8	93.5	102.1	102.8
15	400	0.75	46.7	68.6	82.3	87.8	89.9

Table 5. Additional profit per cow for various differences between sexed and conventional semen and between female and male calf price for cows in parities 1 and 2 (US$).

The difference between sexed and conventional semen price	The difference between female and male calf price	Relative conception rate of sexed semen compared to conventional semen (RCR)	Additional profit per cow					
			Number of sexed semen services					
			1	2	3	4	5	6
			parities 1					
20	100	0.80	-25.8	-42	-50.8	-57.5	-61.9	-64.7
20	100	0.75	-32	-52.8	-64.9	-74.03	-80.2	-82.7
20	200	0.80	-10.7	-17.8	-20.9	-23.9	-25.8	-27.1
20	200	0.75	-25.1	-40.6	-52.2	-60.3	-64.2	-68.1
20	300	0.80	4.3	6.4	9.1	9.8	10.2	10.6
20	300	0.75	-3.9	-6.9	-7.5	-9.0	-9.8	-10.0
20	400	0.80	19.4	30.6	39.0	43.4	46.3	48.2
20	400	0.75	10.2	16.1	21.2	23.6	25.2	27.9
15	100	0.80	-20.8	-34.0	-40.7	-46.2	-49.7	-49.8
15	100	0.75	-27.1	-44.6	-54.5	-62.3	-67.4	-69.3
15	200	0.80	-5.8	-9.8	-10.8	-12.5	-13.6	-14.3
15	200	0.75	-13.0	-21.7	-25.9	-29.7	-32.3	-32.5
15	300	0.80	9.3	14.4	19.1	21.1	22.5	23.3
15	300	0.75	1.1	1.3	2.8	2.9	3.1	4.4
15	400	0.80	24.3	38.6	49.1	54.8	58.5	61.0
15	400	0.75	15.2	24.2	31.5	35.3	37.9	41.3
			parities 2					
20	100	0.80	-27.9	-48.6	-66.9	-81.9	-95.3	-108.1
20	100	0.75	-34.4	-63.3	-87.4	-107.8	-126.6	-145.2
20	200	0.80	-13.5	-25.2	-38.1	-49.7	-61.0	-72.7
20	200	0.75	-21.0	-41.3	-60.1	-77.1	-93.9	-111.4
20	300	0.80	0.9	-1.8	-9.3	-17.5	-26.8	-37.2
20	300	0.75	-7.5	-19.2	-32.8	-46.5	-61.2	-77.5
20	400	0.80	15.2	21.7	19.5	14.7	7.5	-1.7
20	400	0.75	5.9	2.8	-5.5	-15.9	-28.5	-43.7
15	100	0.80	-22.9	-40.5	-56.7	-70.3	-82.8	-95.0
15	100	0.75	-29.5	-55.1	-76.9	-95.8	-113.6	-131.5
15	200	0.80	-8.6	-17.0	-27.8	-38.1	-48.5	-59.5
15	200	0.75	-16	-33.0	-49.6	-65.2	-80.9	-97.6
15	300	0.80	5.8	6.4	0.9	-5.9	-14.3	-24.1
15	300	0.75	-2.6	-11.0	-22.3	-34.5	-48.2	-63.8
15	400	0.80	20.2	29.8	29.7	26.2	20.0	11.4
15	400	0.75	10.9	11.06	4.9	-3.9	-15.5	-29.9

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Table 6. Additional genetic gain (±SE) in milk yield (kg) due to the economically optimum use of sexed semen and estimating *BV*s by traditional method.

	Relative conception rate of sexed semen compared to that of conventional semen (RCR)	
	0.80	0.75
	Traditional method	
Heifer	103.32±5.2	103.32±5.2
Parity 1	81.20±4.7	79.59±3.1
Parity 2	78.92±7.1	77.49±6.2
Weighted average	89.45	88.53
	Genomic method with 3k panel	
Heifer	144.59±7.3	144.59±7.3
Parity 1	108.68±7.2	105.05±8.1
Parity 2	108.27±6.2	103.04±5.3
Weighted average	122.94	120.34
	Genomic method with 50k panel	
Heifer	157.18±2.4	157.18±2.4
Parity 1	122.98±3.1	112.47±3.3
Parity 2	118.93±5.3	114.45±1.6
Weighted average	135.61	130.87

Weighted average was calculated according to the ration of each group and the gain of that group.

[DOR: 20.1001.1.16807073.2014.16.4.14.4]

female and male calf price was US$400; secondly, when the difference between sexed and conventional semen price was US$15 and the difference between female and male calf price was US$300-400. Using sexed semen for all services was not profitable for cows in parities 2.

Additional Genetic Gain Resulting from the Economically Optimum Use of Sexed Semen

According to the results of economic evaluation in Iran's market, use of sexed semen for heifers was economically justified in all insemination services and all *RCRs*. For cows in parities 1 and 2 and for *RCR* equal to or more than 0.75, up to two services with sexed semen was economical. In this section, the additional genetic gain due to this economically optimum use of sexed semen was estimated.

The additional genetic gains in 305- day milk yield due to the optimal use of sexed semen for *RCR* 0.80 and 0.75, for heifers and cows in parities 1 and 2 using *TE*, GE3k and GE50k are shown in Table 6. The simulation results showed that performing selection on female calves born from heifers resulted in more genetic gain than cows. For *RCR* values of 0.80 and 0.75, there was little difference between genetic gains in female calves born from cows in parities 1 and 2 because, in both of them, sexed semen was assumed to be used up to two services.

The *BV* prediction method greatly influenced the results; for example, for *RCR= 0.80*, the additional genetic gains in milk yield due to sexed semen utilization were 89.45, 122.94, and 135.61 kg using traditional evaluation (TE), genomic evaluation (GE) 3k, and GE50k, respectively. The additional genetic gain resulting from *TE* was about 73% of GE3k and 66% of GE50k, and for GE3k, it was about 90% of GE50k.

Costs of Genomic Testing versus Gain

Cost of genetic testing was not considered in economic evaluation in the current research. According to our results, using GE50k and GE3k resulted in, respectively, 53.46 and 41.27 kg more genetic gain than

TE in milk yield of calves born from heifers. If we assume that calves would have three lactations and discount rate per year is 12%, the present value of gain per calf born from heifers would increase by US$8.41, US$6.49 using GE50k and GE3k, respectively, compared to *TE*. Thus, it is obvious that the cost of genomic testing is not justified only by using sexed semen.

DISCUSSION

Economic Evaluation of Sexed Semen

According to the results shown in Table 2, the profit per heifer would increase by about US$91, US$73, and US$57 for *RCR* values of 0.80, 0.75, and 0.70, respectively, if all services are performed by sexed semen. The estimated profitability of using sexed semen in heifers in the current study was more than the estimated profitability of using it in some other studies. This difference was mainly due to the higher price of female calves in Iran. De Vries (2010) estimated the increase of profit per heifer at most by US$9. Olynk and Wolf (2007) concluded that the optimal use of sexed semen would be to use it only for the first service and its profitability was about $38 for *RCR= 0.75*, when conception rate at all insemination services was 0.65.

The profit per heifer increased much more than per cow. It was due to the difference in their pregnancy rates. The lower pregnancy rate in cows would result in lower profit. This result was in agreement with previous studies (Olyk and Wolf, 2007; De Vries, 2010).

Additional Genetic Gain Due to Sexed Semen Utilization

Presently, improving the milk yield is the basic goal in breeding program of dairy cattle in Iran, and the selection of sires is mainly based on this trait due to the absence of milk quota system and the pricing system. The genetic gain in 305-day milk yield resulting from this breeding program in Iranian Holstein herds is about 53 kg per year (Sahebhonar, 2008). Using sexed semen could accelerate genetic gain due to the higher selection intensity in females, although selection on sires is still more important resource for genetic improvement; for example, for *RCR= 0.80*, the additional genetic gains in 305-day milk yield due to the optimal use of sexed semen were about 89.45, 122.9, and 135.6 kg by *TE*, GE3k, and GE50k, respectively. Only female calves would have these genetic superiorities, they are 22.5% of the female population and 67% of them are born from heifers and cows in parities 1 and 2. We could conclude that for *RCR= 0.80*, the additional genetic gains were about 13.28, 18.25, and 20.13 kg per year using *TE*, GE3k, and GE50k, that is about 25, 34 and 38% of the current genetic gain, respectively. For *RCR* lower than 0.80, the additional genetic gain resulting from using sexed semen would certainly decrease.

The increase of genetic gain due to using sexed semen could be obtained when sexed semen straws of genetically elite sires are available, and the dairy farmers should pay great attention to this issue. De Vries (2010) stated that the sexed semen is usually not available from the best sires. Hutchison and Norman (2009) stated that from 717 active Holstein bulls born after 1994, 211 (about 29%) had sexed semen available in 2008. The bulls with sexed semen available are slightly better than average active bulls for milk yield traits, productive life, daughter pregnancy rate, and net merit, and they are slightly superior for somatic cell score, calving ease, and still birth.

Effects of Sexed Semen on the Management of Dairy Cattle Farms

In addition to genetic gain, sexed semen has some suitable effects on management of dairy cattle farms. Female calves are smaller than male calves and, therefore, use of sexed semen would decrease the incidence rate of dystocia.

Norman *et al.* (2010) concluded that the use of sexed semen reduces percentage of birth with dystocia by 28% (from 6 to 4.3%) for heifers and 64% (from 2.5 to 0.9%) for cows. The other benefit of using sexed semen could be extending the lactation length. Weigel (2004) suggested that the average lactation length of high-producing dairy cows could be extended to 18, 20, or even 24 months because these cows could easily provide their own replacements if sexed semen is used for their insemination. The other benefit of sexed semen utilization could be bio-security. The current study assumed that the herd size would be approximately fixed. By utilizing sexed semen, it is also possible to expand herds without purchasing heifers or cows from other farms; consequently, farms are not exposed to new pathogens and there is bio-security for expanded farms.

In conclusion, using sexed semen for heifers in Iran's current economic conditions could be suggested for all insemination services. However, for the cows, the reproductive management of dairy farms should be carefully considered. Using sexed semen up to two services for cows in parities 1 and 2 in reproductively well-managed farms is profitable, while in weakly-managed reproductive farms, where *RCR* is equal to or lower than 0.70, sexed semen utilization is not profitable. The genetic progress would accelerate if dairy farmers use sexed semen. In this study, for *RCR= 0.80*, additional genetic gain was about 25, 34, and 38% higher than the current genetic progress in 305-day milk using *TE*, GE3k and GE50k, respectively.

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جنبه ها اقتصادی و پیشرفت ژنتیکی استفاده از اسپرم تعیین جنسیت شده در ارزیابی ژنومیک و سنتی در گاوهای شیری هلشتاین ایران: یک مطالعه شبیه سازی

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چکیده

در سالهای اخیر اسپرم تعیین جنسیت شده به طور تجاری در دسترس قرار گرفته است. به دلیل قدرت باروری کمتر و قیمت بیشتر نسبت به اسپرم معمولی، قبل از توصیه این تکنولوژی به تولیدکنندگان گاو شیری در هر کشور باید ارزیابی اقتصادی انجام شود. اهداف تحقیق حاضر عبارت بودند از: ارزیابی سود و زیان حاصل از به کار بردن اسپرم تعیین جنسیت شده در سطح مزرعه در شرایط اقتصادی ایران براساس ارزش فعلی خالص کل خالص (Total Net Present Value: TNPV) و تخمین اثر اسپرم تعیین جنسیت شده بر نرخ پیشرفت ژنتیکی در جمعیت گاو شیری با و بدون به کار بردن اطلاعات ژنومیک. نرخ باروری اسپرم تعیین جنسیت شده به اسپرم معمولی (Relative Conception Rate of sexed semen (RCR) compared to conventional semen) برابر با ۰/۸، ۰/۷۵ و ۰/۷ فرض شد. نرم افزارهای ویژوال بیسیک ۶ و Excel برای محاسبات در این تحقیق به کار برده شد. نتایج نشان داد که تعداد بیشتر تلقیح با اسپرم تعیین جنسیت شده در تلیسه ها منجر به TNPV بالاتر برای همه RCR ها می شود ولی برای گاوهای شکم اول و شکم دوم به کار بردن دو تلقیح با اسپرم تعیین جنسیت شده برای RCR های برابر با ۰/۸ و ۰/۷۵ به بالاترین TNPV منجر می شود و برای RCR=۰/۷ به کار بردن اسپرم تعیین جنسیت شده اقتصادی نبود. بهره ژنتیکی افزوده شده در تولید شیر ۳۰۵ روز با به کار بردن روش سنتی، ارزیابی ژنومیک با تراشه 3k و ارزیابی ژنومیک با تراشه 50k تقریبا ۲۵٪، ۳۴٪ و ۳۸٪ بیشتر از پیشرفت ژنتیکی سالانه کنونی برای این صفت در ایران است.