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SOME FACTORS AFFECTING PRODUCTION AND MILK COMPOSITION CHARACTERS IN A CROSSBREEDING EXPERIMENT INVOLVING GABALI AND V- LINE RABBITS IN EGYPT

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Abstract: Data from 662 litters and 221 samples (two replicates per each sample) of rabbit milk were collected from three different genetic groups [Gabali (G), V-line (V) and G×V (F_1)] to study the effect of line and of some non-genetic factors affecting production and milk composition traits. The studied traits were: number born alive (LSBA); litter size at weaning (LSW); litter weight born alive (LWBA); litter weight at weaning (LWW); total milk yield (TMY) and protein, fat, total solids (TS), ash, phosphorus (P), potassium (K), sodium (Na), calcium (Ca) and magnesium (Mg) milk content. The genetic group effect was significant for LSBA [V (7.3) and F_1(7.3) were superior to G (6.6)); LWBA (higher values for V (416 g) and F_1 (405 g) than for G (382 g)]; TMY [G (3497 g) and F_1(3486 g) higher than V (3042 g)]; milk fat [F_1 (26%) and G (25%) superior to V (23%)] and milkTS [F_1(42%) superior to G (40%) and V (39%)]. The estimates of the heterosis effect ranged between 1.6% and 12.8% for production and milk gross chemical traits, being significant only for milk fat content (9.1%). The positive values of the heterosis estimates for those traits and the complementarity between the G breed and the V line, the G superior in milk related traits but the V superior in prolificacy, show the interest of their cross and of the synthetic lines derived from them. The heterosis was non-significant for milk mineral content traits. The parity effects were significant for LSBA, fat, TS, ash and K (the maxima were reached at 6th or 5th parity). The effect of week of lactation was significant for fat, ash and TS, corresponding the maximum values of fat and TS to the 3rd and 4th week. The year-season or the year-month effects were significant for all traits showing the importance of including these time-period factors into the statistical models proposed for the traits.

Key words: Rabbits, heterosis, litter traits, milk composition.

INTRODUCTION

Milk production is an important factor in rabbit production. Milk yield and milk components determine the rate of growth of the newborn rabbits (Khalil *et al.,* 2004). There are many traits correlated with rabbit milk production and its composition such as litter size at weaning, litter weight at weaning or mortality in lactation (Mehaia *et al.,* 2002; Khalil *et al.,* 2004; Al-Sobayil *et al.,* 2005).

Crossbreeding is one of the breeding methods to improve some traits. Khalil *et al.* (2004) and Al-Sobayil *et al*. (2005) cited that crossbreeding in rabbits gave favorable heterotic effects on milk production and its composition. One promising breed in Egypt is the Gabali, commonly raised under Egyptian desert conditions, characterized by heavy litter weight at weaning (Afifi, 1997; Abd El-Aziz, 1998 and Afifi, 2002). An interesting line, performing well in hot climates, is the V line, a synthetic line originated in 1982 at the Department of Animal Science, Universidad Politécnica, Valencia, Spain, selected for litter size at weaning (Estany *et al*., 1989). The V line is important as a source to found

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new lines in many countries (Garreau *et al*., 2004) and it is envisaged the foundation of a synthetic line between the Gabali breed and the V line. The interest of a synthetic line between two different sources of animals depends on the complementarity and heterosis between both.

Not too much studies have been carried out concerning milk production and its composition in rabbits respect other species, because milk sample collection and recording milk production are difficult, and more knowledge is needed about the performance of different breeds in these traits. In order to fill the lack of knowledge of differences between breeds in milk production and composition and to check the interest in crossbreeding to found a new synthetic line, a study is proposed to compare the Gabali breed, the V line and the F_1 cross between them.

MATERIALS AND METHODS

Animals and breeding plan

Animals used in this study were Sinai Gabali bought from Bedouins living in northern Sinai, V line rabbits and the crossbreds (F_1) between them. The V line rabbits were imported by the Faculty of Agriculture, Alexandria University, Egypt from Valencia, Spain, in 1999. The animals were housed in the Department of Animal Production, Faculty of Agriculture at Moshtohor, Egypt. Sinai Gabali bucks were mated to V-line does to get the F_1. The data structure showing the genetic groups of does and their parents are given in Table 1. The bucks were randomly assigned to mate naturally with 3 or 4 does avoiding mating of animals with common grandparents. Does were mated on the day of kindling. Kits were weaned at 28 d after kindling.

Rabbits were raised in one floor farm, oriented from east to west that has windows and fans to control the ventilation. There are regular electric heaters in winter to keep the minimum degree of temperature at 15ºC. In summer, there are fans and forced air cooling to keep the maximum of temperature at 35ºC. Breeding bucks and does were housed separately in individual wired-cages. In the rabbitry, temperature ranged from 15 to 35ºC, the relative humidity ranged from 30 to 70% and photoperiod was set at 16L:8D. Breeding animals were fed *ad libitum* a pelleted rabbit ration containing 18.1%

Table 1: Number of does and parents of does (sires and dams) by genetic group and trait

Genetic group of does	No. litters/samples	Does	Sires	Dams
Production traits				
Sinai Gabali (G)	142	66	17	27
V-Line (V)	422	165	70	91
G×V (F_1)	98	48	15	28
Total	662	279	102	146
Gross chemical composition of milk				
Sinai Gabali (G)	61	32	16	20
V-Line (V)	99	56	41	47
G×V (F_1)	61	34	13	21
Total	221	122	70	88
Mineral content of milk				
Sinai Gabali (G)	45	18	8	10
V-Line (V)	57	39	31	32
G×V (F_1)	36	24	9	18
Total	138	81	48	60

crude protein, 13.7% crude fiber and 2.28% fat. All cages were equipped with feeding hoppers and drinking nipples. Cages of all breeding animals were cleaned and disinfected before each kindling. Manure was collected daily and moved outside the rabbitry. All animals were managed similarly throughout the experimental period.

Collected Data

The recorded traits were sorted in three classes: production traits, milk gross chemical composition traits and milk mineral content traits. The production traits were recorded on 662 litters produced by 279 does (Table 1) and included number born alive (LSBA), litter size at weaning (LSW), litter weight born alive (LWBA), litter weight at weaning (LWW) and total milk yield (TMY). The milk gross chemical composition traits were recorded on 221 samples (two replicates per sample) coming from 122 does (Table 1). Five or more does of each genetic group were randomly chosen per week of lactation (weaning at 28d) during time-periods between April 2004 and April 2005. Milk samples were collected manually at 8 am by gently massaging the mammary gland of does after allowing their young to suckle for only 30 seconds. These samples were cooled for each doe separately and then transferred immediately to the Dairy Laboratory, for chemical analysis. The samples were analyzed for protein, fat, total solids (TS), and ash according to the methods of the British Standard Institute (BSI, 1988), International Dairy Federation (IDF, 1987), IDF (1993) and AOAC (1990), respectively. The milk minerals were also recorded on 138 samples (two replicates per sample) coming from 81 does (Table 1), from April 2004 to July 2004, and were analyzed for phosphorus (P), potassium (K), sodium (Na) and magnesium (Mg) according to the methods described by AOAC (1990) and calcium (Ca) that was determined according to the method described by IDF (1992).

Statistical analyses

Data on production and milk composition were analyzed by generalized least squares using the procedure mixed of SAS (Statistical Analyse System, 1996) according to the following mixed models:

a) For production traits:

$$X_{ijklm} = \mu + A_i + b_{ij} + P_k + Y_l + e_{ijklm} \qquad \text{(Model 1)}$$

b) For milk composition traits:

$$X_{ijklmn} = \mu + A_i + b_{ij} + P_k + Y_l + L_m + e_{ijklmn} \qquad \text{(Model 2)}$$

Where: X_{ijklm} or X_{ijklmn} is an observation, μ is the overall mean; A_i is the fixed effect of genetic group; b_{ij} is the random effect of doe within genetic group; P_k is the fixed effect of parity; Y_l is the fixed effect of year-season in the Model 1 and year-month in the Model 2; L_m is the fixed effect of week of lactation and e_{ijklm} or e_{ijklmn} are the random errors.

Heterosis was computed as: (average of the F_1 – average of the two purebreds), and the percentage of heterosis as: [heterosis / average of the two purebreds]×100.

RESULTS AND DISCUSSION

Genetic groups

Results presented in Table 2 show that the genetic group effect was significant (P<0.05) for LSBA and LWBA and highly significant (P<0.01) for TMY, but non-significant on LSW and LWW. The V line and the F_1 were superior to the Gabali breed for LSBA and LWBA. Conversely, Iraqi *et al*. (2006) found that genetic group effect was non-significant for LSBA and LWBA, but significant (P<0.05) for LSW and LWW in a crossbreeding experiment between New Zealand White and Gabali breeds carried out in Egypt. It is also shown in Table 2 that the Gabali breed and the F_1 had significantly higher TMY than the V line.

Table 2: Least-squares means of factors (mean±standard error) affecting number born alive (LSBA), litter size at weaning (LSW), litter weight born alive (LWBA, g), litter weight at weaning (LWW, g) and total milk yield (TMY, g).

Effect		LSBA	LWBA	LSW	LWW	TMY
Genetic group		*	*			***
	Gabali (G)	6.61^{a}±0.28	382^{a}±13	5.35±0.31	1868±133	3497^{a}±154
	V-Line V)	7.26^{b}±0.16	415^{b}±8	5.31±0.18	1767±80	3042^{b}±96
	G×V (F_1)	7.33^{b}±0.30	405^{b}±15	5.74±0.32	2050±138	3486^{a}±167
Heterosis (unit)		0.40±0.28	6±14	0.41±0.30	233±129	216±153
Heterosis (%)		5.71%	1.61%	7.69%	12.83%	6.63%
Year-season		***	***	***	***	***
	Autumn 2003	6.87±0.37^{bc}	428±18^{ab}	5.57±0.38^{abc}	1964±162^{ab}	3644±200^{ab}
	Autumn 2004	6.15±0.26^{cd}	349±13^{c}	4.50±0.28^{c}	1710±113^{b}	3063±137^{c}
	Winter 2004	7.90±0.29^{a}	426±14^{ab}	6.54±0.29^{a}	2298±127^{a}	3749±154^{a}
	Winter 2005	7.03±0.28^{bc}	407±14^{ab}	5.33±0.30^{bc}	1791±121^{b}	3194±156^{c}
	Spring 2004	8.14±0.25^{a}	392±12^{bc}	5.97±0.26^{ab}	1794±108^{b}	3296±128^{bc}
	Spring 2005	7.56±0.42^{ab}	450±21^{a}	5.53±0.68^{abc}	1782±267^{b}	3221±316^{bc}
	Summer 2004	5.83±0.35^{d}	356±17^{c}	4.82±0.34^{c}	1925±137^{ab}	3222±174^{bc}
Parity		*				
	1st	6.83±0.17^{b}	390±8	5.37±0.19	1823±75	3170±94
	2nd	6.80±0.22^{b}	401±11	5.46±0.23	1961±90	3327±112
	3rd	7.13±0.28^{ab}	411±14	5.60±0.31	1913±122	3416±147
	4th	6.91±0.35^{ab}	390±17	5.26±0.38	1892±149	3327±186
	5th	7.26±0.50^{ab}	401±25	5.48±0.49	1863±192	3461±238
	6th	7.61±0.54^{a}	409±27	5.79±0.61	1977±239	3502±288
	7th	6.94±0.53^{ab}	405±26	5.30±0.55	1838±2226	3188±303

*= P<0.05; **=P<0.01; ***=P<0.001. Means in a column for each factor that do not share any superscript are significantly different.

Results presented in Table 3 show that the least square means of genetic groups for fat and TS were significantly different, but not significant for protein and ash. The F_1 showed significant higher contents of fat than the V line and higher contents of TS than the Gabali breed and the V line. These means were higher than those reported by Al-Sobayil *et al.* (2005) in different genetic groups of rabbits (Saudi Gabali, line V and different crosses between them) raised in Saudi Arabia where they found 12.9±2.3, 2.2±0.3 and 29.1±3.0% for fat, ash and TS, respectively. El-Sayiad *et al.* (1994) reported that the differences between NZW and Californian rabbits were not significant for fat, protein, lactose and ash content in their milks. The means of these traits were 14.0±3.0, 13.6±4.0, 1.9±1.0 and 2.1±1.0% in NZW and 14.0±3.0, 14.3±4.0, 2.0±1.0 and 2.2±1.0% in Californian rabbits, respectively.

Results in Table 4 show that there were non-significant effects of genetic groups for mineral content in rabbit's milk. Peaker and Taylor (1975) found that Na content was 24 ppm in milk of the Dutch breed, which was lower than that obtained in this study. No more references are available for genetic group effect on mineral content in rabbit milk.

Heterosis

Results in Tables 2, 3 and 4 showed that there was a significant heterotic effect for fat and TS, but it was non significant for the other traits. When comparing the two purebreds to the F_1, it was noticeable

Table 3: Least-squares means of factors (mean±standard error) affecting gross chemical composition of milk (%).

Effect		Protein	Fat	Total solids (TS)	Ash
Genetic group			*	**	
	Gabali (G)	9.84±0.21	24.64^{ab}±0.96	39.93^{a}±0.90	3.26±0.20
	V-Line V)	9.66±0.15	23.11^{a}±0.71	38.61^{a}±0.67	3.01±0.15
	GxV (F_1)	9.93±0.22	26.05^{b}±0.99	41.93^{b}±0.93	3.19±0.21
Heterosis (unit)		0.18±0.23	2.18±1.08*	2.66±1.01**	0.06±0.22
Heterosis (%)		1.85%	9.13%	6.77%	1.91%
Year-month		***	***	***	*
	April 2004	9.26±0.21^{b}	27.25±0.86^{a}	42.74±0.80^{a}	2.91±0.20^{c}
	May 2004	10.04±0.2^{a}	24.12±0.78^{bc}	39.72±0.73^{b}	2.88±0.19^{c}
	June 2004	9.99±0.23^{a}	24.99±0.88^{ab}	40.01±0.83^{b}	2.96±0.22^{bc}
	July 2004	10.09±0.22^{a}	24.74±0.86^{b}	40.74±0.81^{ab}	2.96±0.22^{bc}
	March 2005	10.49±0.19^{a}	22.43±0.76^{c}	39.27±0.71^{b}	3.52±0.19^{ab}
	April 2005	8.98±0.22^{b}	24.06±0.85^{bc}	38.45±0.80^{b}	3.69±0.22^{a}
Parity			***	***	*
	1st	9.41±0.17	23.18±0.70^{c}	38.12±0.66^{b}	3.21±0.16^{ab}
	2nd	9.95±0.17	24.43±0.68^{bc}	40.59±0.64^{ab}	2.70±0.17^{b}
	3rd	9.54±0.18	23.91±0.74^{bc}	39.68±0.69^{b}	3.25±0.18^{ab}
	4th	10.04±0.26	23.51±0.96^{bc}	40.21±0.90^{b}	3.38±0.25^{ab}
	5th	10.03±0.30	26.25±1.05^{ab}	40.22±0.99^{b}	2.90±0.29^{ab}
	6th	9.90±0.30	28.32±1.16^{a}	42.87±1.09^{a}	3.47±0.29^{a}
	7th	9.79±0.39	22.60±1.50^{c}	39.42±1.41^{b}	3.16±0.38^{ab}
Week			***	***	**
	1st	9.62±0.19	23.28±0.73^{b}	38.74±0.69^{b}	3.45±0.19^{a}
	2nd	9.91±0.15	23.07±0.60^{b}	39.21±0.57^{b}	2.99±0.14^{a}
	3rd	9.73±0.15	25.83±0.63^{a}	40.87±0.59^{ab}	2.89±0.15^{b}
	4th	9.97±0.20	26.21±0.76^{a}	41.82±0.72^{a}	3.29±0.20^{a}

*= P<0.05; **=P<0.01; ***=P<0.001. Means that in a column for each factor do not share any superscript are significantly different.

that crossing Gabali with V line was associated with positive heterotic effects on production and milk gross chemical composition. The percentage of heterosis ranged from 1.61 to 12.83% and 1.85 to 9.13% for production traits and gross chemical components, respectively. Iraqi *et al.,* (2006) found a significant estimate of direct heterosis for LSBA, that was of moderate importance and negative (decreased the general mean by 4.03%). Baselga *et al.* (2003) have studied the crosses between several maternal lines (line A is NZW; lines V and H are synthetic lines). Line A showed significant individual heterosis with lines V and H for total born and LSBA. Heterosis estimates ranged between 0.45 and 0.98 young per litter (4 and 10%). Abd El-Aziz *et al.* (2002) showed that direct heterotic effects on milk production traits were non-significant (0.12 to 2.4%). Khalil *et al.* (2004) reported that heterotic effects were positive and most of them significant, ranging from 9.7 to 22.7% and from 3.2 to 15.8% for rabbit milk yields and gross chemical composition, respectively. The positive values of the heterosis estimates for these traits and the complementarity between the G breed and the V line, the G superior in milk related traits but the V superior in prolificacy, show the interest of their cross and of the synthetic lines derived from them. Al-Sobayil *et al.* (2005) reported that crossbred does

Table 4: Least-squares means of factors (mean ±standard error) affecting traits of mineral content of milk (ppm).

Effect	Phosphorus (P)	Potassium (K)	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)
Genetic group					
Gabali (G)	25.10±1.29	101.81±8.44	52.86±5.15	2024.6±108.4	558.0±44.4
V-Line V)	22.57±0.95	99.48±6.36	53.23±3.85	1778.9±78.7	540.9±32.7
G×V (F_1)	22.61±1.39	83.04±9.40	46.33±5.68	1791.0±114.5	536.8±47.9
Heterosis (unit)	-1.225±1.47	-17.61±9.82	-6.71±5.96	-110.73±122.7	-12.65±50.8
Heterosis (%)	-5.14%	-17.5%	-12.6%	-11.6%	-2.3%
Year-month	***	***	*	***	***
April 2004	22.54±1.13^{b}	56.66±7.89^{c}	42.71±4.71^{b}	2041.7±90.1^{a}	711.8±38.7^{a}
May 2004	27.23±1.07^{a}	117.34±7.60^{a}	50.36±4.50^{ab}	2096.0±83.3^{a}	592.8±36.5^{b}
June 2004	20.99±1.32^{b}	110.64±9.36^{ab}	50.33±5.55^{ab}	2188.1±103.1^{a}	554.3±45.1^{b}
July 2004	22.96±1.22^{b}	94.46±8.69^{b}	59.83±5.15^{a}	1133.4±95.7^{b}	322.1±41.9^{c}
Parity		***			
1st	23.34±1.10	92.34±7.55^{bc}	49.68±4.53	1785.8±88.7	463.4±37.7
2nd	20.76±1.19	77.49±8.35^{c}	37.18±4.98	1751.4±93.9	570.3±40.8
3rd	22.20±1.20	96.48±8.39^{bc}	45.92±5.01	1880.9±95.5	595.5±41.2
4th	23.09±1.74	98.89±12.48^{bc}	63.96±7.38	1775.4±133.5	533.0±59.3
5th	28.12±1.94	127.32±14.06^{a}	56.24±8.27	1908.5±148.2	574.0±66.1
6th	23.48±1.70	62.37±11.75^{c}	46.11±7.04	1717.5±135.9	620.3±58.3
7th	23.02±2.39	108.55±17.03^{ab}	56.56±10.08	2234.3±185.2	460.2±81.6
Week					
1st	23.17±1.20	108.68±8.56	52.73±5.07	2033.3±94.0	623.0±41.1
2nd	22.69±1.01	91.74±7.14	44.53±4.23	1887.3±79.0	527.7±34.4
3rd	23.50±0.99	90.95±7.01	48.32±4.15	1825.3±77.8	531.2±33.8
4th	24.36±1.29	87.73±9.38	57.64±5.51	1713.5±99.5	499.0±44.1

*= P<0.05; **=P<0.01; ***=P<0.001. Means that in a column for each factor that do not share any subscript are significantly different

and dams involving V-line genes gave favorable and positive direct heterosis effects on the gross chemical composition of milk (P<0.05 - 0.01). Estimates of heterotic effects for mineral traits in the present study were negative and ranged from −17.5% to −2.3%.

Year-season

The results in Table 2 show that year-season had a strong influence (P<0.001) on all the production traits. Also, means of LSW and LWW were the highest in winter 2004 compared to the other year-season combinations. Means of LSBA and LWBA were significantly (P<0.001) higher in spring 2004 and spring 2005, respectively, than in other year-seasons. These results are in agreement with the findings of Nasr (1994) and Enab *et al.* (2002). Means of TMY had the highest values (P<0.001) in winter 2004 (3749.1 g), followed by autumn 2003 (Table 2). The same trend was observed by Ramadan (2005) on NZW rabbits. However, Hassan *et al.* (1992) observed non-significant effect of season on TMY in NZW rabbits.

Year-month

Results in Table 3 showed that year-month combinations were significant (P<0.05 or 0.01) for all gross chemical composition traits and the highest means of TS (42.74%±0.80) and fat (27.25%±0.86) were obtained in April 2004. Conversely, the lowest means for these traits were 38.45%±0.80 and 22.43%±0.76, obtained in April 2005 and March 2005, respectively. However, the highest means of ash (3.69%±0.22) and protein content (10.49%±0.19) were obtained in April 2005 and March 2005, respectively. These results were in accordance with that of Nasr (1994) who found that milk yield and some associated traits were significantly affected by season of kindling of rabbits does.

Results in Table 4 showed that effect of year-month combinations were significant (P<0.05 and P<0.001) on all mineral content traits. The highest means of P and K content were obtained in May 2004. The highest means of Na, Ca and Mg content in milk were obtained in July 2004, June 2004 and April 2004, respectively. This reflects the important effect of year and month combinations on both gross chemical and mineral traits of rabbit's milk under the Egyptian conditions and shows the need of including them into the models of analysis of these traits.

Parity

Parity effect (Table 2) was not a significant source of variation in most studied production traits, exception of LSBA which was significant. These results agree with that obtained by Abd El-Aziz (1998), Barakat (2001) and Ramadan (2005). The means of LSBA had the lowest values at the 1st and 2nd parity, and the highest at the 6th parity. The same results were observed by Ramadan (2005). Sedki *et al.* (2002) reported that the effect of parity on kit weight at weaning was significant (P<0.05 or 0.01). An increment of milk production with the parity order has been reported (McNitt and Lukefahr, 1990; Hassan *et al,* 1992) that could be correlated to the development of the mammary glands.

Effect of parity order on fat, TS and ash content in milk (Table 3) was significant (P<0.05 or 0.001). These results were in accordance with those of Khalil (1994), El Sayiad *et al*. (1994) and Pascual *et al*. (1999). Means of fat, TS and ash showed the lowest values at the 1st parity and the highest at the 6th parity, following a trend consistent with the development of the mammary glands and the physiological capacity of the does. El-Maghawry *et al*. (1993) and Nasr (1994) found that milk production, feed and digestible energy intake during lactation increased linearly with the parity order. The effect of parity order on milk mineral content traits was only significant for K content (P<0.001, Table 4). The maximum level of K was obtained in the 5th parity.

Week of lactation

Week of lactation significantly affected fat, TS and ash content, but its effect was non-significant on protein (Table 3). During the 4th week of lactation, concentration of most milk components for the previous traits was the highest. This may be due to the decrease of daily milk yield in the fourth week of lactation (El-Maghawry *et al.,* 1993; Nasr, 1994). Peaker and Taylor (1975), Kamar *et al.* (1985) and Lebas *et al.* (1997) reported that rabbit milk in the 4th week of lactation becomes markedly richer in protein (15.1%) and fat (20 to 22%). They added that milk production drops rapidly after the end of the third week of lactation. The decrease is even swifter if the doe has been fertilized immediately after kindling as occurred in this experiment. Peaker and Taylor (1975) showed that labeled lactose amount increased during the late lactation. Kamar *et al.* (1985) found a negative correlation between the milk yield and its content of fat, protein and total solids.

Week of lactation effect was not a significant factor for any of the milk mineral content traits, (Table 4). Peaker and Taylor (1975) found that Na decreased from early stages to medium stages of lactation (11-14 days) and then increased, whereas, K and lactose showed inverse pattern to that displayed by Na. They added that glucose entry from blood into milk was positively correlated with Na and inversely correlated with K and lactose.

CONCLUSIONS

Considering prolificacy and milk related traits, the Gabali breed and the V line show complementarity. The Gabali is superior in milk yield and milk gross chemical composition but the V line is superior in number born alive and litter weight born alive.

The heterosis effects in production and milk gross chemical composition traits are positive. This fact, together with the previously mentioned complementarity suggests possible use of the cross between Gabali and the V line and of their synthetic.

The time-period effects are important sources of variation for all the traits studied, indicating the importance of including them in the model.

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