Selection for self-fertility in rye inbred lines

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ABSTRACT

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Observations made on the response to selection for self-fertility in inbred lines of cultivated rye *(Secale cereale)*, *S. montanum* and *S. anatolicum* are statistically analyzed. The lines investigated have been inbred for 11, 12, 15 and 17 generations. Consanguinity has been forced by selfing.

The regression coefficient of the fertility (measured as seed setting) on the consanguinity, the plant-offspring correlation and the coefficient of variation of the fertility have been analyzed. The meaning and application of the obtained results are discussed.

INTRODUCTION

Rye is an allogamous plant with a genetic system of self-incompatibility (LUNDQVIST, 1954, 1956) which normally prevents self-pollination. Nevertheless, the obtention of self-fertile inbred lines is interesting for certain programmes of rye breeding. So, for instance, SÁNCHEZ-MONGE (1958) used self-fertile inbred lines as rye parents to obtain *Triticale* plants, thus overcoming the barrier of their low fertility.

The obtention of rye inbred lines at the Estación Experimental de Aula Dei was started about 1949-50; the consanguinity having since been maintained without interruption by selfing. At the present moment inbred lines with from 10 to 20 years of consanguinity are available.

In this paper the results obtained by selection for self-fertility in several rye inbred lines are presented.

MATERIAL AND METHODS

Five inbred lines of cultivated rye, *Secale cereale* L., from as many different Spanish localities, namely *Villarrobledo, Granada, Biota, Huesca* and *Riodeva,* are involved in this investigation. Likewise another inbred line of *Secale cereale* named *Pool* —obtained from an initial admixture of equal amounts of seeds of several Spanish sources— has been utilized.

One inbred line of each of the two species *Secale montanum* and *Secale anatolicum* are also included in this investigation.

Self-fertilization was forced each generation by bagging together the ears of each plant. Fertility was measured in percentage of seed setting, assuming that the spikelets have two florets.

Every generation the seeds harvested from the plant with the highest fertility gave rise to the following generation in each inbred line. A random sample of plants would be bagged at maturity, their fertility measured and those with the highest fertility selected, and so on. In this way it was possible to relate the fertility of each selected plant in a given generation with that of its offspring in the following generation.

Statistical treatment of fertility percentages was made after the BLISS's transformation: $\theta = \text{arc. sin} \sqrt{\text{percentage}}$.

RESULTS

In figures 1 to 8, the variation of the fertility (expressed as θ values) of the selected plants (▲) and that of their offsprings (●) for each generation of inbreeding is shown. Likewise, the fluctuations of the coefficient of variation (o) is indicated.

By statistical treatment of the above values, it has been possible to obtain and analyze:

1) the regression of offspring fertility on consanguinity (Tab. 1)
2) the regression of fertility of the offsprings on the plants they arise from and the plant-offspring correlation (Table 2)
3) the values of the coefficient of variation of fertility within each plot (offspring) in each generation (Table 3).

TABLE 1. — *Regression coefficients of the offspring fertility (plots) on consanguinity.*

Inbred line	*Number of generations of inbreeding analyzed*	*b*	S_b	*t*	*P*
Secale cereale Villarrobledo	15	— 0.3125	0.519	0.6021	> 0.5
» » Granada	15	2.81	0.52	5.40	< 0.001***
» » Biota	15	0.55	0.58	0.95	0.4-0.2
» » Huesca	13	1.15	0.68	1.69	0.2-0.1
» » Ríodeva	13	2.30	0.505	4.55	< 0.001***
» » Pool	10	4.01	1.87	2.14	0.1-0.05
Secale montanum	10	1.51	1.28	1.18	0.4-0.2
Secale anatolicum	10	— 0.032	0.81	0.039	> 0.5

TABLE 2. — *Regression coefficient of fertility of the plot (offspring) on plant ($b_{y.x}$) and coefficient of correlation* (r) *plant-offspring (plot).*

Inbred line	*f.d. (n—2)*	$b_{y.x}$	*r*	*Confidence interval* 5 %	1 %
Secale cereale Villarrobledo	8	0.22	0.235		
» » Granada	8	0.60	0.689*	0.105-0.920	—
» » Biota	8	0.44	0.351		
» » Huesca	8	0.35	0.302		
» » Ríodeva	8	0.25	0.403		
» » Pool	8	0.41	0.565		
Secale montanum	8	0.64	0.816**	0.383-0.955	0.169-0.971
Secale anatolicum	8	0.097	0.156		

The minimum significant values of the correlation coefficients at the 5 % and 1 % significance levels are 0.632 and 0.765, respectively.

Calculations of the confidence intervals of the correlation coefficient has been made after the formula $z \pm t \cdot s_z$ (SNEDECOR, 1964, table 7-6-1).

TABLE 3. — *Values in percent of the coefficient of variation of the offspring fertility, indicating the number of plants considered in each plot.*

Inbred line	Inbreeding generation																
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
S. cereale							71	57	18	8.5	13	13	33	15	36	27	C V
Villarrobledo							10	4	4	4	4	4	6	10	7	16	n
S. cereale							59	89	46	27	82	13	27	8.3	18	18	C V
Granada							10	4	4	4	4	4	4	6	9	22	n
S. cereale							19	30	21	15	9.1	1.2	6.6	12	81	140	C V
Biota							10	4	4	4	4	2	4	8	2	2	n
S. cereale					59	98	16	33	23	15	24	16	17	27			C V
Huesca					10	4	4	4	4	4	4	12	9	19			n
S. cereale					32	8.4	10	11	32	2.9	18	9.4	21	12			C V
Ríodeva					20	4	4	4	4	2	4	4	12	19			n
S. cereale	66	53	35	24	4.6	33	14	15	26	16							C V
Pool	30	4	4	4	4	2	4	3	10	10							n
S. montanum		86	72	11	33	36	4.5	22	48	25	28						C V
		14	4	4	4	4	4	4	6	4	7						n
S. anatolicum	9.7	8.8	19	16	14	22	12	15	25	14							C V
	12	4	4	4	4	4	4	5	4	13							n

C V means coefficient of variation in %.
n means the number of plant considered in each plot (offspring).

One can deduce from Table 1 that the regression of offspring fertility on consanguinity is highly significant (P < 0.001) only in the inbred lines *Granada* and *Riodeva* of *Sécales Cereale.* Except for the inbred line *Villarrobledo* of *S. cereale* and the one of *S. montanum* in which the statistical results of the regression give small accuracy, the remainder inbred lines give statistical significance with error probabilities between 40 % and 20 % and between 10 % and 5 %.

The obtained values of the regression coefficients range from 0.55 to 4.01 (those of *Villarrobledo* and *S. montanum* are not taken into consideration), being worthy of mention that the significant values found in the inbred lines *Granada* and *Riodeva* are rather similar to each other (2.81 and 2.30, respectively).

From figures 1 to 8 and from Table 3, it is found that the coefficients of variation of fertility in the offsprings in each inbred line (except for the line *Biota*) reach levels ranging from 15 % to 30 %, both in cases of 17 and 11 years of inbreeding. In all cases (excepted the *Secale anatolicum* inbred line) it seems that the values obtained fall off rapidly since a given (not always the same) degree of consanguinity.

DISCUSSION

As indicated in the Introduction of this paper, the obtention of self-fertile inbred lines of rye is important to overcome the barrier of fertility in *Triticale* breeding. As a rule the rye genome changes the allogamous status of its natural condition into an autogramous status (SÁNCHEZ-MONGE, 1958); this change might be the cause of the low fertility of *Triticale* since the rye genome within the *Triticale* nuclei is in homozygous condition and, that for, self-incompatibility phenomena can take place (LACADENA, 1965). This is the reason why, using self-fertile inbred lines of rye has given good results in *Triticale* breeding.

The selection for high fertility made in our material each generation has opposed the typical depression originated by consanguinity in rye, both at diploid and tetraploid level (LUNDQVIST, 1953, 1969). The positive response observed is in agreement with that previously reported by SYBENGA (1958).

From the results obtained one can deduce that, as a rule, the selection for high fertility (measured as percentage of seed setting) in our material not only maintains but even increases the level of fertility notwithstanding the increasing degree of consanguinity. (Table 1).

The lack of statistical significance of the correlation between the fertility of each selected plant and its offspring (as seen in Table 2), might be attributed to the higher selective value of heterozigosis in the loci responsible for the characters related to fertility. Similar cases have been reported by MÜNTZING (1963) and LUNDQVIST (1969). However, the similar behaviour of the coefficients of varia-

FIGURES 1 to 8. Plant and offspring fertilities (measured as θ values) plotted against the number of inbreeding generations. The offspring (plot, ●) in a given year arises from the plant (▲) of the preceding generation of inbreeding (see the text).
Coefficients of variation (o) (in per cent) of the offspring fertility plotted against the number of inbreeding generations.

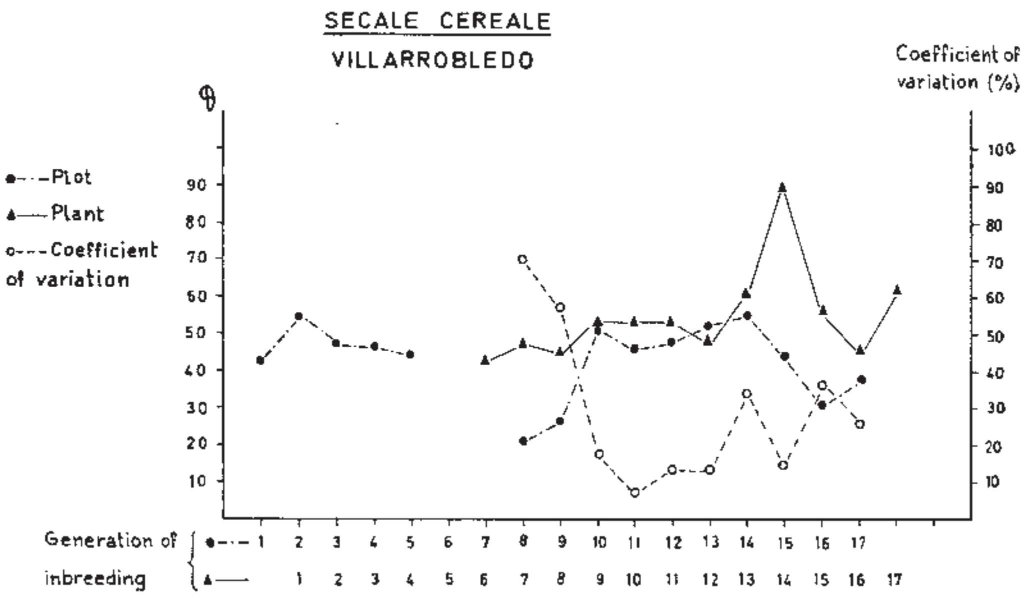

FIG. 1

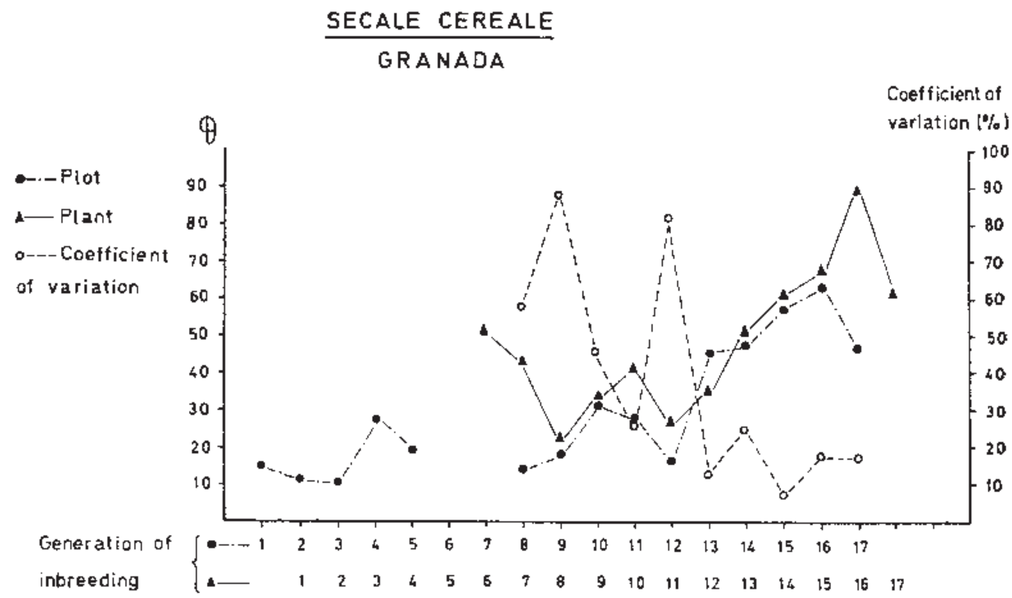

FIG. 2

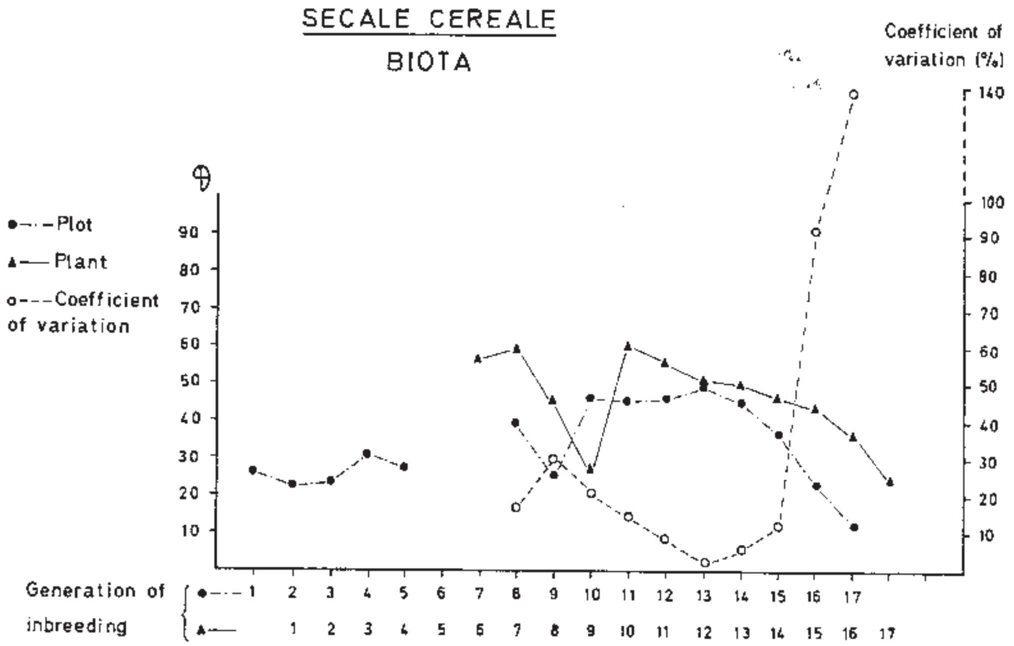
SECALE CEREALE
BIOTA
Coefficient of variation (%)
Plot
Plant
Coefficient of variation
Generation of inbreeding

FIG. 3

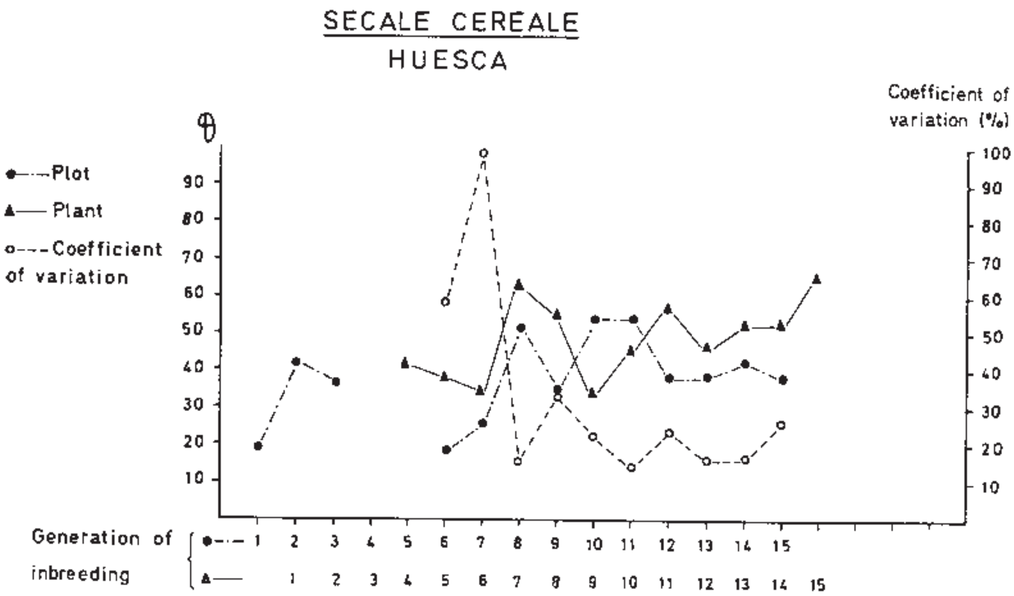
SECALE CEREALE
HUESCA
Coefficient of variation (%)
Plot
Plant
Coefficient of variation
Generation of inbreeding

FIG. 4

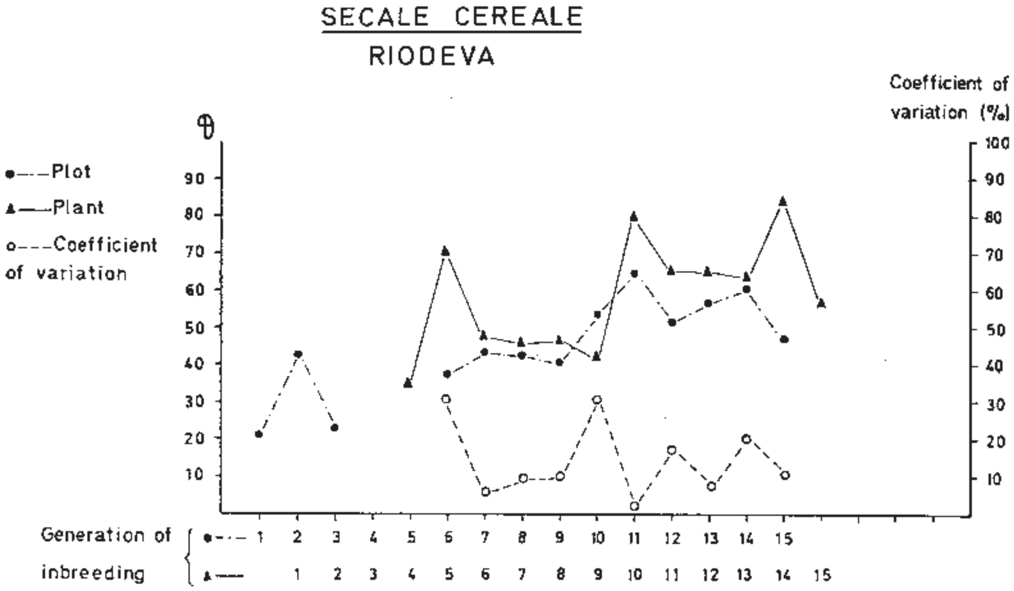
SECALE CEREALE
RIODEVA
Coefficient of variation (%)
●—·—Plot
▲——Plant
○---Coefficient of variation
Generation of inbreeding

FIG. 5

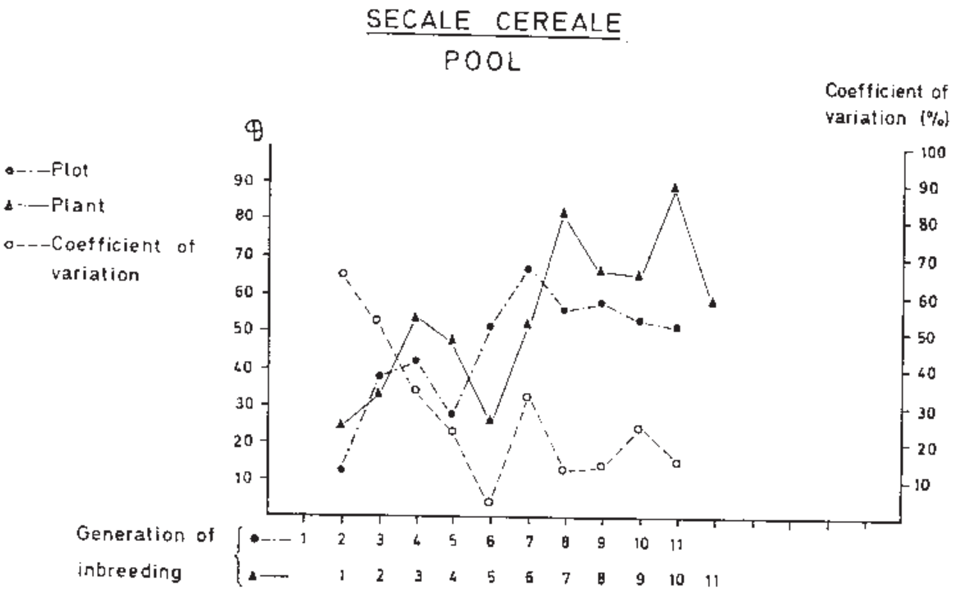
SECALE CEREALE
POOL
Coefficient of variation (%)
●—·—Plot
▲——Plant
○---Coefficient of variation
Generation of inbreeding

FIG. 6

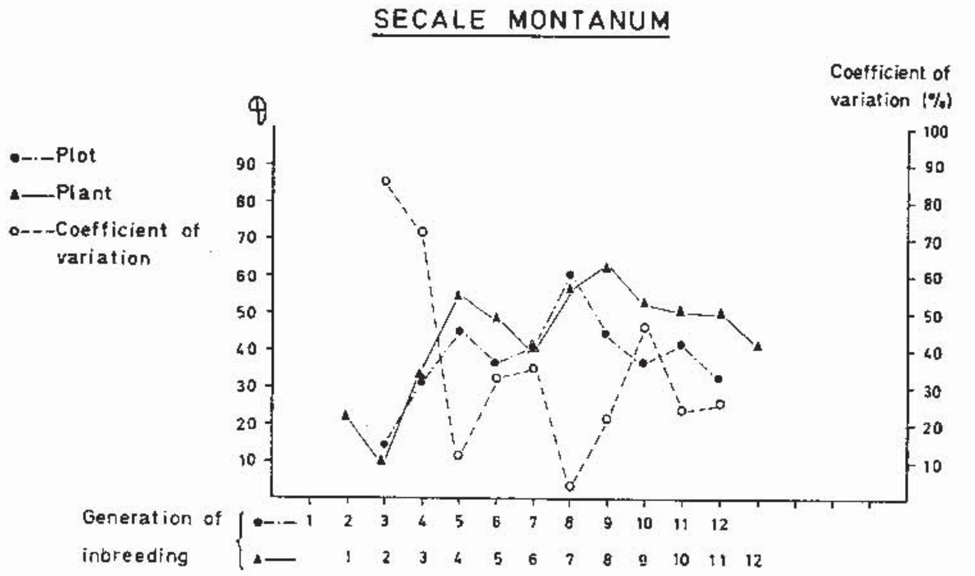
SECALE MONTANUM
Coefficient of variation (%)
•-·-Plot
▲—Plant
o---Coefficient of variation
Generation of inbreeding

FIG. 7

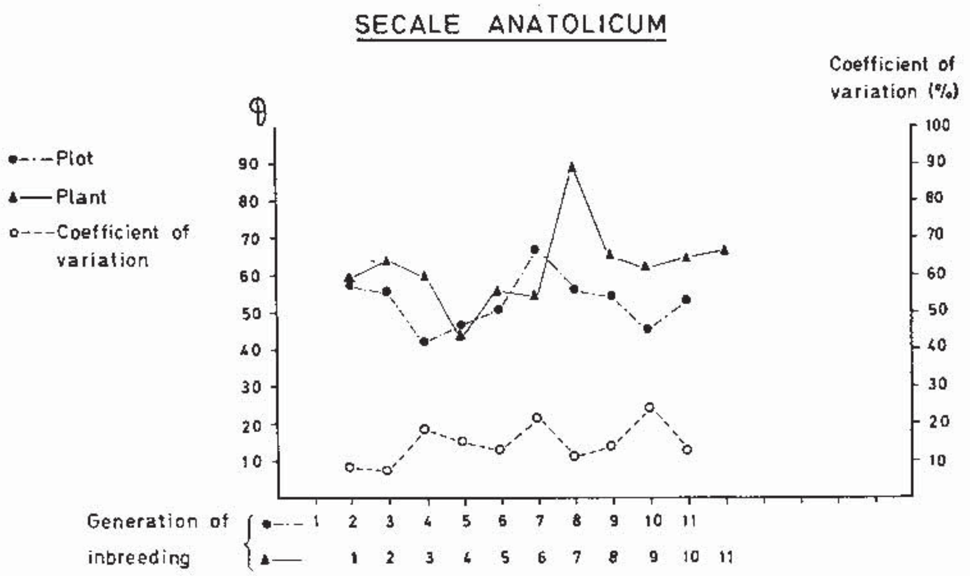
SECALE ANATOLICUM
Coefficient of variation (%)
•-·-Plot
▲—Plant
o---Coefficient of variation
Generation of inbreeding

FIG. 8

tion of fertility found in the different inbred lines seems to reflect the expected gradual increase of homozygosis (Table 3). Thus, it seems reasonable to think that the non significant plant-offspring correlations might be due to the environmental influence on the phenotypic expression of such a complex character as fertility.

RESUMEN

Se resumen las observaciones realizadas en diferentes líneas consanguíneas de centeno (con 11, 12, 15 y 17 años de consanguinidad) seleccionados para autofertilidad.

Se calculan los coeficiente de regresión de la fertilidad (expresados en cuajado de semilla) con la consanguinidad, la correlación de la fertilidad planta-descendencia y los coeficientes de variación de la fertilidad en cada generación. Se discute el valor y aplicación de los resultados obtenidos.

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