IODINE CONTENT OF PASTURE PLANTS

II. INHERITANCE OF LEAF IODINE CONTENT OF PERENNIAL RYEGRASS
(LOLIUM PERENNE L.)

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Summary

Leaves of single plants of perennial ryegrass grown on the same soil were analysed for total iodine, using material from diallel crosses.

Despite considerable variation in the levels, total iodine was shown to be a strongly inherited character.

Maternal effects were also demonstrated.

I. INTRODUCTION

In two earlier publications (Butler and Johnson 1957; Johnson and Butler 1957), considerable differences in iodine contents were reported for different pasture species and varieties growing on the same soil. From analyses of single plants of perennial ryegrass, it was concluded that leaf iodine content is an inherited character. The evidence is presented here in detail.

II. EXPERIMENTAL

The experimental material consisted of a number of single plants of New Zealand certified perennial ryegrass, which were grown in the field on Manawatu silt loam, a friable alluvial soil.

A preliminary survey was made of the leaf iodine contents of 13 parent plants (taken at random) which were growing as clonal pairs in a holding block of plants selected for vigour. Leaf material was bulked from both plants of each parent.

On the basis of these analyses, leaf material from diallel crosses of four of these parent plants was collected and analysed for total iodine. This material was available in a randomized block layout consisting of 5 blocks, in which each plot contained two 5-plant rows, one of the cross and one of its reciprocal. These were sampled on October 7, 1956, 14 months after planting out.

Clean leaf material was sampled from two separate plants of each 5-plant row, sufficient being collected to be representative of each plant. Ten single-plant lots for each one-way cross were thus obtained.

The samples were air dried at 60°C in a forced-draught oven, and ground in a Wiley mill. Single chemical determinations for total iodine were made on each sample by the method of Johnson and Butler (1957). Check duplicate analyses carried out on the original parent clonal material always differed by less than 1%.

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The maximum error in duplicate analyses carried out on a wider range of plant material had previously been found to be 2% (Johnson and Butler 1957).

III. Results

The leaf material from the 13 randomly chosen parent plants gave iodine contents ranging from 18.5 to 247.0 µg/100 g dry weight.

The results of chemical analyses of diallel crosses of four of these parent plants are shown in Figure 1. The analysis of variance for the data in Figure 1 is shown in Table 1.

![Diagram](image)

**Fig. 1.—Mean iodine contents (µg/100 g dry wt.) and standard errors for a 4 × 4 diallel crossing system. Cross means are written adjacent to the female parent.**

The subdivision of the sum of squares for crosses in the above analysis was made using the method set out by Griffing (1956) for one set of F₁'s and reciprocal
F₁'s, excluding parents, and regarding effects as constants for the fixed set of genotypes examined.

Although no population inferences can be made about combining abilities or heritability, it is clear that iodine content has a genetic basis. It should be noted, in addition, that parental data have been excluded from the above analysis, although the significantly high means for those crosses involving parent H₁ are shown in Figure 1 to be related to the high iodine value for that parent.

The coefficients of variation per single plant were high, ranging from 40% to 79% within the two-way crosses, with a mean of 64%.

The possibility of a maternal effect was further tested by means of a modification of the method of Chandraratna and Sakai (1960).

The genetic model is shown pictorially in Figure 2, where P₁ and P₂ are two parents with means x₀ and y₀, the two reciprocal crosses have means x₁ and y₁, a is the mid-parent value, and F₁ represents the F₁ mean when there is no maternal effect, but a dominance of P₁ over P₂ of h. The coefficient of maternal effect is designated m.

\[
\begin{align*}
P₁ & \quad P₂ \quad P₁ + P₂ \quad a \quad x₀ - h m \quad (x₀ - h m) \quad y₀ - h m \quad P₁ \quad P₂ \nend{align*}
\]

Fig. 2.—Genetical model of maternal effect. See text for definition of symbols.

Since only the first generation is involved, the genetical model can be represented by the equations

\[
x₁ = a(1-m) + h(1-m) + mx₀,
\]

and

\[
y₁ = a(1-m) + h(1-m) + my₀,
\]

From the data available, 12 prediction equations for m were obtained by insertion of all possible values of the parents and crosses, m and its variance being estimated by the method of least squares (for example, see Mather 1949). The following significant maternal effect was found:

\[
m = +26.4 \pm 7.0%.
\]

It will be noted, from Figure 1, that the (L₁ × L₂) and reciprocal cross are rather anomalous, as both sides of the cross exceed either parent, so that there is apparent heterosis, or this may be simply a result of inaccurate measures of either parent because of inadequate replication in the preliminary survey. When this cross and reciprocal were omitted from the data, a significant maternal effect remained, as follows:

\[
m = +25.2 \pm 7.8%.
\]
When the procedure was again applied, using data from the six crosses with the highest parent only, the maternal effect was

\[ m = +14.6 \pm 8.1\% \]

This is barely significant, but serves to show that the earlier significant results were not simply caused by one high parent in the data.

IV. Discussion

It will be noted that the coefficients of variation reported are high. These contrast markedly with coefficients of variation of plant weight of perennial ryegrass single plants grown from seed, which are usually stable and of the order of 30% in such selected material.

Inaccuracies introduced in the chemical procedure can be discounted as a source of variation, and it is felt that the thorough sampling of the leaf material carried out cannot account for more than a very small fraction of the remaining variability. The high coefficients therefore suggest that either a high genetic variance remains in single plants of any cross, or that there is great variation in soil iodine available to the plants.

Little is known about the state of combination of soil iodine, but on the basis of \(^{131}I\) studies, Raja and Babcock (1961) concluded that it is mainly associated with "non-living" organic matter.

The data in Figure 1 show that manipulation of the leaf iodine content of perennial ryegrass is possible by judicious plant selection. This has encouraged further work at this station on genetic and environmental variation in herbage constituents, which will be presented elsewhere.

Work on cytoplasmic inheritance in Epilobium (reviewed by Michaelis 1956) appears to provide the only previous demonstration of clear-cut maternal effects on the levels of chemical constituents of higher plants. Ross (1941) observed maternal effects on the levels of auxin, starch, anthocyanin, and tannin and also on peroxidase activity. It is clear that the possibility of maternal effects should be investigated for other constituents.

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