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VARIABILITY OF COUCH (ELYTRIGIA REPENS (L.) DESV.) IN GRASSLANDS AND ARABLE FIELDS IN TWO LOCALITIES IN THE NETHERLANDS

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SUMMARY

Shoots of couch (*Elytrigia repens* (L.) Desv.) were collected from several grasslands and arable fields from a sand-and a clay area in The Netherlands and grown to adult plants on one experimental field. After three months these plants showed considerable variability which partly appeared to be related to the land use and locality of the sampled fields. However, land use and locality never accounted for more than 10% of the total variation of the observed plant characteristics. This variability could not be attributed to characteristics of the planted shoots and therefore seemed to be genetically determined and consequently the result of selection of couch types by the environment. The ways in which the land use (grassland versus arable land) might have caused the selection of the couch types are discussed.

1. INTRODUCTION

In temperate climates, couch (*Elytrigia repens* (L.) Desv.) is considered to be one of the most serious weeds on cultivated soils; this is probably due to its ability to form rhizomes. The species is very variable (JANSEN 1951; PALMER & SAGAR 1963; POOSWANG et al. 1972) and clear indications have also been found that couch populations in different areas can be composed of different genotypes (WILLIAMS 1973; BULCKE et al. 1974).

In a comparison of spaced plants collected from grasslands, arable fields and leys in The Netherlands (NEUTEBOOM 1975) the characteristics within and between different provenances of couch were also found to vary greatly. In that experiment, in which collections of couch plants were grown on one experimental field, plants collected from arable fields were found to have formed rhizomes that were markedly thicker than those from plants collected from grasslands, whilst plants collected from leys had rhizomes of an intermediate diameter. However, the number of arable fields sampled (3) was too small to allow further systematic comparisons to be made between the plants from grasslands and arable fields. Therefore, a new experiment was set up to compare plants collected from 16 grasslands and 32 arable fields in two localities in the eastern part of The Netherlands – one on clay and the other on sand.

2. MATERIALS AND METHODS

In February and March 1974 shoots or pieces of rhizome were collected from couch plants in 8 grasslands and 16 arable fields, in two localities; the Betuwe (river clay) and the Achterhoek (sand) (i.e. from 16 grasslands and 32 arable fields in all). The grasslands were at least 100 years old and in several cases did not have much couch growing, whereas the only arable fields sampled were those that, according to farmers' information, were typical couch-infested fields.

With a few exceptions the grasslands varied in size from 1 to 2 or 3 ha. Some arable fields were much larger, but in fields larger than 1 ha a square of 100 × 100 m was always sampled in the middle of the field. Ten shoots of couch were collected in each of the grasslands. In each of the arable fields 5 shoots or pieces of rhizome were collected along diagonals. For two months these shoots and rhizome pieces were grown in jiffy pots in a glasshouse at a diurnal temperature range of 15–20°C and natural day length. During this period the developing plantlets were clipped twice to stimulate tillering. At the end of May one small shoot was selected from each plantlet and, after another week in the glasshouse, was planted out in an experimental field on a sandy soil.

The shoots were planted in a random scheme, spaced 80 cm apart: 160 grassland shoots (16 fields × 10 shoots) and 160 shoots from arable fields (32 fields × 5 shoots); 320 shoots in all. Two months before planting the experimental field had been dressed with 60 kg/ha P_2O_5 and 120 kg/ha K_2O. Two weeks after planting a nitrogen dressing of 60 kg/ha was applied.

Before planting the selected shoots had been characterized by counting their leaves and by measuring the total shoot length, the length and width of the largest leaf and the diameter of the shoot base. The characteristics of the shoots from the two study areas did not differ significantly, but the grassland shoots still tended to have more, and somewhat larger, leaves *(table 1)* than the shoots from arable fields.

Table 1. Characteristics of the planted shoots; means of 160 shoots from arable fields and 160 shoots from grasslands.

	shoot length (cm)	number of leaves	total leaf area (cm^2)	mean diameter shoot base (mm)
Plants from:				
arable fields	15.2	1.41**	2.36**	1.82
grasslands	15.6	1.60	3.15	1.85

* $P < 0.05$; ** $p < 0.01$

The plants were dug up in the second week of September, one week after their growth habit had been classified as prostrate (1), intermediate (2) or erect (3) (NEUTEBOOM 1975). A distinction was made between *parent plants*, which had developed by direct tillering of the planted shoots, and *daughter plants*, which had grown from rhizomes. The growth habit and the number of shoots and ears always refer to the parent plants. When measuring the dry weights of shoots, roots and rhizomes, the whole plant (including any daughter plants on its rhizomes) was weighed. The length and volume of the two longest rhizomes were determined. To determine their volume the rhizomes were immersed in a water-filled burette and the quantity of water displaced was measured.

3. RESULTS

3.1. Growth and development of the plants in the whole plant collection

By September the planted shoots had developed into very variable plants with an average dry weight of 23 g. This variability is illustrated by the fact that most of the observed morphological characteristics and characteristics concerning numbers (shoot number, ear number and number of daughter plants) did not correlate, or correlated only slightly *(table 2)*. The strongest correlation (r = 0.42)

Table 2. Correlations between the plant characteristics in September (320 plants)
(1: length × width of the largest leaf).

	growth habit	leaf size[1]	length longest rhizome	vol/cm longest rhizome	shoot number	ear number	number of daughter plants	dry weight: shoots	dry weight: roots	dry weight: rhizomes
leaf size	ns									
longest rhizome	ns	ns								
vol/cm longest rhizome	0.18**	0.42**	ns							
shoot number	ns	ns	ns	ns						
ear number	0.25**	0.27**	ns	ns	0.32**					
number daughter plants	ns	0.14*	ns	ns	ns	ns				
dry weight shoots	0.16**	0.37**	ns	0.24**	0.66**	0.57**	0.21**			
dry weight roots	ns	0.32**	ns	0.18**	0.50**	0.44**	0.21**	0.79**		
dry weight rhizomes	0.23**	0.43**	0.39**	0.43**	0.36**	0.30**	0.27**	0.50**	0.43**	
total dry weight	0.20**	0.44**	0.24**	0.35**	0.60**	0.52**	0.26**	0.94**	0.76**	0.83**

ns: not significant; * $p < 0.05$; ** $p < 0.01$

was found between the leaf size (length × width of the largest leaf) and the volume per cm length of the longest rhizome, but even this means that at the most, one characteristic could account for 18 % of the variation of the other. In spite of a high rhizome production (on average, 46 % of the total plant dry weight), 30 % of the plants had still not produced daughter plants from rhizomes by September. However, 75 % of the plants had formed ears. The late planting of the shoots (end of May) was probably the reason why such a high proportion of plants had not produced daughter plants by September. Contradictory to WIL-

LIAMS (1973) who found no clear relationships between the root, shoot and rhizome dry weights of couch plants raised from different seed collections, in my experiment these characteristics appeared to be clearly positively correlated (*table 2*; correlation coefficients (r) varying from 0.43 to 0.79). In fact, rhizome and shoot dry weights as the only characteristics showed a slight but significant quadratic relationship ($r^2 = 0.47$).

3.2. Differences between the plants of the grasslands and arable fields of the Betuwe and the Achterhoek

3.2.1. General picture

As in my previous experiment (NEUTEBOOM 1975), some plant collections from arable fields again formed very thick rhizomes, but clear indications of a systematic difference between the plants from grasslands and arable fields with regard to this characteristic were only found within the Betuwe collection; the plants collected from grasslands and arable fields in the Achterhoek behaved differently with regard to their rhizome: shoot ratio.

However, in both localities the plants from grasslands and from arable fields had systematically differed in growth habit, number of shoots, number of ears and root dry weight. The latter two differences were possibly related to the difference in the number of shoots.

Growth habit and number of ears were also clearly related to the locality (Betuwe, Achterhoek) and besides the rhizome thickness and rhizome : shoot ratio also some other characteristics showed an interaction of locality and land use. These differences will be explained in more detail below.

3.2.2. Illustration of the effects of the land use and locality

Table 3 summarizes the means of the observed plant characteristics: it shows the means for each of the plant collections from the grasslands and arable fields in the Betuwe and the Achterhoek and the means of the characteristics of all the plants collected. The table also presents F-values obtained from analyses of variance of the characteristics; F-values of the effects of the land use (U; grassland, arable land) and the locality (L; Betuwe, Achterhoek) of the original sampled fields. However, as the shoots planted from the grasslands and arable fields initially had slightly different characteristics, and secondly, as the characteristics of the plants in September appeared to have a slight linear correlation with these original shoot characteristics (r varying from not significant to 0.15, 320 plants), the effects of U and L have been adjusted for these characteristics of the planted shoots. Naturally, this means that part of a real L- or U-effect may have been wrongly attributed to the characteristics of the original first shoots, but there is no way of finding out to what extent this occurs. However, since the correlations were low, the original shoot characteristics never removed more than 1 to 2 percent of the total variation compared with the 5 to 10% that was explained by very significant effects of U and L.

In both plant collections, the grassland plants were, on average, more pros-

Table 3. Means of the plant characteristics in September and F-values (F^1_{312}) of the effects of U (use), L (locality) and U × L with these characteristics. F-values adjusted for the characteristics of the first shoots (*table 1*). GRL = grasslands, ARL = arable fields.

	MEANS					F^1_{312}		
	Betuwe		Achterhoek		All plants	Use	Locality	U × L
	GRL n=80	ARL n=80	GRL n=80	ARL n=80	n=320			
Parent plant								
growth habit	1.5	1.9	2.0	2.4	1.9	18.516***	33.188***	0.008
leaf size (cm²)	23.4	25.4	28.2	25.9	25.7	0.012	7.161**	4.411*
shoot number	60.1	40.0	56.5	36.7	48.4	33.605***	1.524	0.019
ear number	2.9	1.9	4.1	3.0	3.0	9.269**	11.328**	0.003
Daughter plants								
number	3.8	2.2	4.6	4.4	3.8	1.414	4.310*	0.742
Longest rhizome								
length (cm)	67.4	62.7	58.5	56.7	61.3	2.562	22.778***	0.482
vol/cm	5.5	7.2	6.0	6.6	6.3	27.658***	0.229	6.780*
Dry weight (g)								
shoot	11.4	9.2	14.6	10.1	11.3	13.670***	4.791*	3.515
root	1.9	1.3	2.2	1.4	1.7	22.181***	2.875	1.685
rhizome	10.5	9.8	10.7	11.1	10.5	0.291	0.204	0.073
total	23.7	20.7	27.5	22.6	23.6	6.941**	3.886	1.180

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

trate and had significantly more tillers, more ears and a higher root dry weight than the plants from arable fields. However, growth habit and number of ears also strongly differed between the two localities; the Achterhoek plants were clearly more erect and had formed more ears than the Betuwe plants. *Fig. 1* presents a frequency distribution of the numbers of shoots of the plants from the grasslands and arable fields and shows that there was also considerable variation within these two plant collections. *Fig. 2* further illustrates the effects of U and L on the growth habit of the plants. The effects of U and L on the mentioned characteristics cannot be attributed to deviating plant groups of individual fields.

The plants from arable fields in the Betuwe and Achterhoek had formed thicker rhizomes than the plants from grasslands (*table 3;* volume per cm of the longest rhizome). However, as mentioned earlier, this difference was only very significant in the Betuwe collection ($p < 0.001$). This was because in the Betuwe collection the grassland plants had more frequently formed thin rhizomes than in the Achterhoek collection. Within the Achterhoek collection the distinction

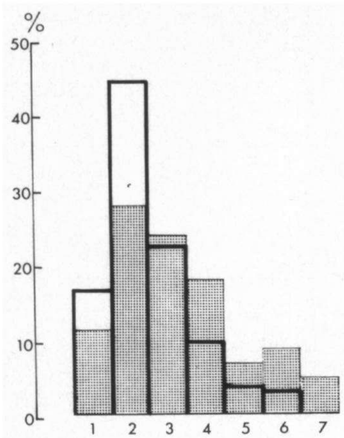

Fig. 1. Histogram of numbers of shoots on the plants; grassland plants (▩) and plants from arable fields (□). Classes of shoot numbers: 1 (>0≤20), 2 (>20≤40), 3 (>40≤60), 4 (>60≤80), 5 (>80≤100), 6 (>100≤120), 7 (>120).

between plants from the grasslands vis à vis plants from the arable fields was only significant at $p < 0.05$.

Land use and locality were also found to affect leaf size: at significant differences between the four plant collections the highest and the lowest mean for this characteristic were those of the two plant collections from grasslands; the grasslands of the Achterhoek and the Betuwe, respectively.

In the Betuwe collection the plants from arable fields actually had thicker rhizomes as well as larger leaves, and as both characteristics appeared to be positively correlated *(table 2)* this suggests that the differences between the plants from grasslands and arable fields with regard to their volume per cm

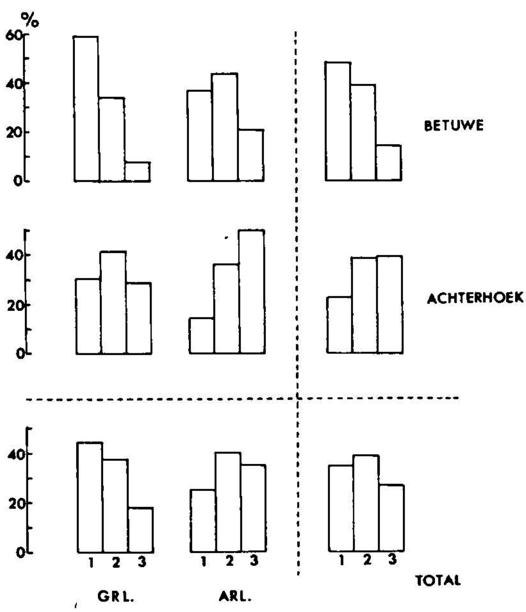

Fig. 2. Histogram of growth habits of the plants. Classes of growth habits: 1 = prostrate, 2 = intermediate, 3 = erect.

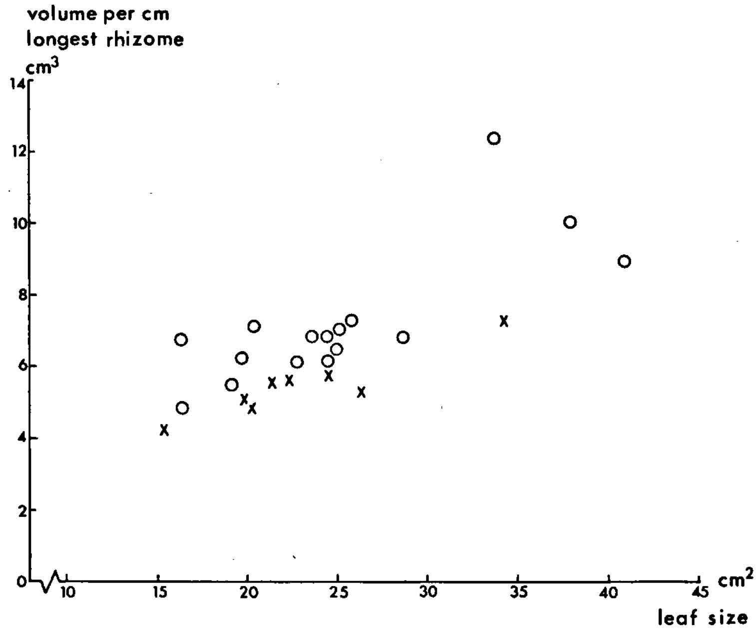

Fig. 3. Mean volume per cm of the longest rhizome and mean leaf size of the plant groups from grasslands (X) and arable fields (O) of the Betuwe.

rhizome could be related to their differences in leaf size. However, *fig. 3* disproves this. In this figure the means per plant for the volume per cm rhizome and for the leaf size of the individual plant groups of the Betuwe are plotted against each other. The plants from the arable fields also with comparable leaf sizes had thicker rhizomes on average than plants from grasslands.

The F-values in *table 3* suggest that land use has a dominating effect on the shoot production of the plants and their total plant dry weight. This is because grassland plants had higher shoot- and higher total plant dry weights than the plants from the arable fields. However, these differences were far more pronounced within the Achterhoek ($p < 0.001$) than within the Betuwe collection ($p < 0.05$).

The plants from grasslands and from arable fields did not differ in rhizome production, but *fig. 4* illustrates that within the Achterhoek collection the grassland plants and the plants from arable fields differed in the relation between their shoot and rhizome dry weights. In this figure the rhizome and shoot dry weights have been plotted against each other for each of the individual plants from arable fields (*fig. 4a*) and the plants from grasslands (*fig. 4b*) of the Achterhoek collection. The plants from the arable fields, with a much stronger correlation between the two characteristics ($r = 0.80$ compared with $r = 0.47$) showed a significantly higher rhizome: shoot ratio than the grassland plants. In fact, plants with a high rhizome: shoot ratio are found in both figures 4a and 4b, but at

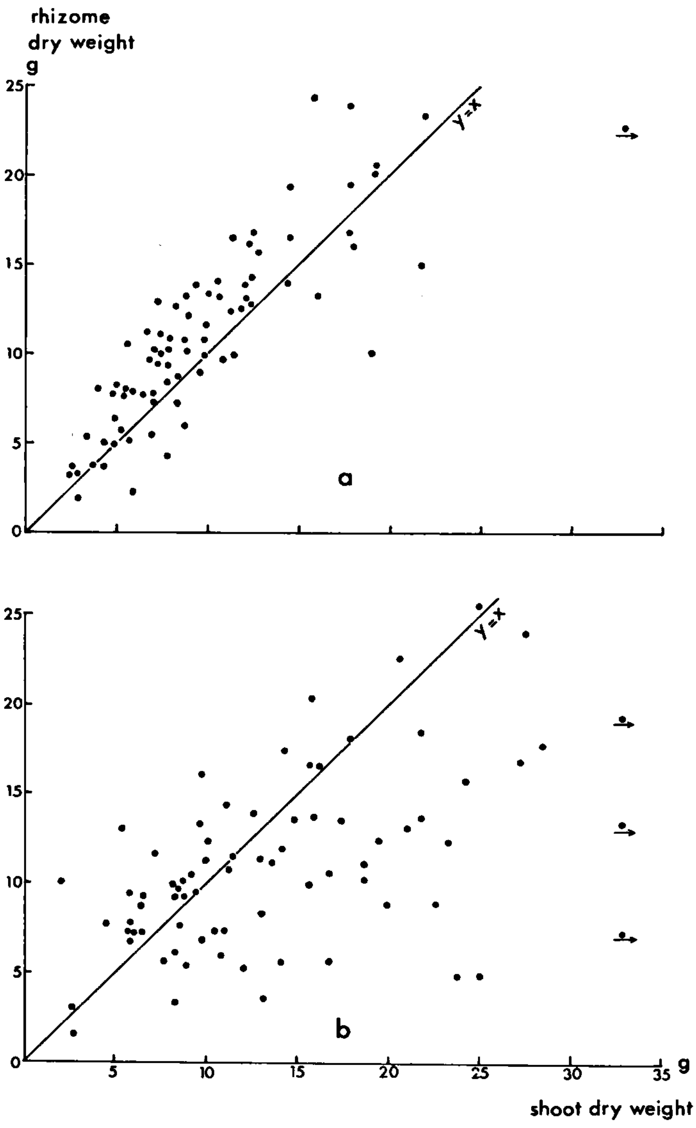

Fig. 4. Relationship between rhizome dry weight and shoot dry weight of the plants from arable fields (a) and grasslands (b) of the Achterhoek.

equal rhizome dry weights the grassland plants had high shoot dry weights more frequently than the plants from arable fields. The mean rhizome : shoot ratios were 1.17 (*fig. 4a*) and 0.93 (*fig. 4b*) and for the plants from the arable fields and grasslands of the Betuwe 1.18 and 1.04, respectively.

Table 3 also shows that locality affected the length of the longest rhizome and the number of daughter plants per plant; the Betuwe plants had formed slightly longer rhizomes but, on average, fewer daughter plants than the plants from the Achterhoek. Within the Betuwe collection the grassland plants had formed more daughter plants than the plants from arable fields ($p < 0.05$). On the other hand, the plants had formed few daughter plants when compared with the number of rhizome tips that were found underground which, in fact, seems to be a more appropriate measure of the potential for daughter plant production. These rhizome tips could not be systematically counted in all plants, but countings in a random sample of 120 plants gave an average number of 40 rhizome tips per plant. However, the grassland plants from the Betuwe collection seemed to have more rhizome tips than this ($p < 0.05$). In other words, within the Betuwe collection the grassland plants had not only formed more tillers, but also seemed to have a greater potential for daughter plant production than the plants from arable land.

4. DISCUSSION

It might be queried if the shoots planted at the end of May were sufficiently characterized by the observed morphological characteristics (*table 1*). However, as neither mineral nutrition nor light intensity could have been limiting during the experiment, it seems unlikely that differences in mineral or carbohydrate content of these first shoots would have seriously affected their further development. It therefore seems reasonable to relate the adjusted effects of the land use and locality on the plant characteristics to the genetic variability of the species. However, the effects of provenance are not easily explicable. This experiment shows that the variability of couch on agricultural soils can also apparently be affected by soil type (clay or sand) or the geographical situation.

Since the numbers of shoots and ears and root dry weight correlated positively, the higher number of ears and higher root dry weight of the grassland plants might be related to the higher shoot number. Studies on some other grass species ('T HART 1947; MAHMOUD et al. 1975) argue that prostrate plants are better adapted to grazing situations, whereas an erect growth habit and thick rhizomes are possibly more suitable characteristics for couch on arable land.

In grassland, prostrate plants may stand a greater chance of escaping from grazing, due to their decumbent shoots, whereas in tall, late-harvested arable crops, more erect plants are possibly more competetive for light.

Strongly tillering couch clones may be better adapted to the growing conditions in grassland because their above-ground plant units have a greater persistence. This has already been suggested by an earlier experiment in which spaced plants of 6 couch clones that strongly differed in tillering were grown from April-planted single shoots and submitted to different clipping regimes (NEUTEBOOM 1975). In that experiment, in two of the strongly tillering clones the number of shoots on the parent plants continued to increase after clippings at 6- and 3-week intervals, right up to the last clipping date at the end of August. However, after an initial increase, the number of shoots on the parent plants of the two weakest tillering clones subsequently decreased. Later observations in a crop situation revealed that in weakly tillering clones the above-ground plant units that develop by tillering from rhizomes can have a limited term of life of less than one growing season, whereas in strongly tillering clones they may remain alive for more than two years.

However, why should strongly tillering clones occur less frequently in arable fields? During the experiment I had the impression that many of the couch plants from arable fields had elongated early and this might have inhibited tillering. In tall, late-harvested arable crops, early stem elongation might be a favourable characteristic in the competition for light, as well.

As a high rhizome : shoot ratio was clearly associated with low shoot numbers ($r = 0.40$; 300 plants), early inhibition of tillering by early stem elongation may also partly explain why plants with a low rhizome : shoot ratio were less frequently found in the plant collections from arable fields. However, stem elongation was not systematically observed and I still cannot explain why plants with a low rhizome : shoot ratio were also found less frequently among the grassland plants of the Betuwe. However, since the grassland plants of the Achterhoek had more robust shoots, shoot size might also be involved in this ratio.

The greater rhizome thickness of couch types in arable fields could be explained first by the greater chance that the larger shoots from thicker rhizomes or rhizome pieces would reach the surface from deeper soil layers after ploughing. Secondly, thick rhizomes might be less susceptible to desiccation when they are brought to the surface by superficial tillage.

In a short experiment, HÅKANSSON (1968) found that thicker rhizomes produced more shoots and that these shoots were more vigorous. He concentrated on the effect of rhizome length on the regrowth from couch rhizomes, but believed shoot production to be a function of the rhizome dry weight, being relatively unimportant if differences in rhizome weight are caused by variations in rhizome length or rhizome thickness. Håkansson found that as the depth of planting was increased, long rhizomes did better than short rhizomes in establishing shoots. This was probably because the longer rhizomes had larger shoots. GRÜMMER (1963) found indications that thicker rhizomes are more drought resistant. Naturally shoot vigour and the total shoot production from rhizomes will also depend on the amount of food reserves, but further (as yet unpublished) analyses of the Achterhoek and Betuwe data have shown that the percentage dry weight and the contents of total soluble carbohydrates and nitrogen are not necessarily different between thick and thin rhizomes. This, however, still means that thick rhizomes will contain more food reserves per unit length. I am unable to explain why the grassland plants from the heavy clay soils in the Betuwe had formed thin rhizomes more frequently than those from the sandy soils in the Achterhoek.

In my first study of the variability of couch (NEUTEBOOM 1975) I found indications that awn length differed between couch populations along different roadsides in the Netherlands. In the present investigation the species also seemed to be geographically variable with regard to its growth habit, rhizome length and ear number. However, since the effects of land use and locality accounted for not more than 10% of the total variation of the observed characteristics, it seems to be difficult to make a sharp distinction between couch types according to the use or locality of agricultural fields on the bases of these characteristics. On the other hand, as illustrated by the volume per cm rhizome in *fig. 3*, a considerable variation in characteristics was still found between the couch populations of the individual sampled fields; this could partly explain why the results of couch control treatments are occasionally so variable.

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