ON THE VARIATIONS IN CONTENTS AND IN INTERRELATIONS OF MINERALS IN DANDELION (TARAXACUM OFFICINALE WEBER) AND PASTURE GRASS [1] [2]

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SUMMARY

Comparisons are made of the mineral constellations of 34 pairs of samples, each consisting of Taraxacum officinale and grass belonging together. Corresponding samples of dandelions and grass were grown in identical conditions. The samples were taken from paddocks of which the soils varied (greatly as regards chemical fertility. Use is made of diagrams (acid-base diagrams, alkalinity diagrams, triangular- and regular tetrahedral-diagrams). Regressions of dandelion to pasture grass are calculated. Its importance in cattle feeding and animal health is discussed.

CONTENTS

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1) Received for publication January 21, 1956.

2) A detailed and more definitive report on minerals in this and other pasture herbs, discussing more analyses than can be summarized here, will be published in future in *"Mededelingen Landbouwhogeschool"* Wageningen.

1. Introduction

On the supposition that their mineral constellations may be favourable to health and production of milk and meat by livestock, much attention is being given at present to the various herbs of pasture. Zürn (1951) and Brünner (1954) have reviewed German literature on the mineral analyses of this group of plants. Thompson (1953) discussed similar articles published in English.

Although the dandelion (Taraxacum officinale Weber) is ons of the most common plants in European pasture, knowledge of its mineral constellations is restricted. Fagan and Watkins (1932), Trünigen and Von Grünigen (1935), Brünner (1954) and Kirchner (1955) reported its contents of K, P and Ca; the first mentioned authors also demonstrated the chlorine content. Only Schulze (1953) and Stichting etc. (1954) each published one complete analyses of its macro-elements. But none of the authors mentioned here, took full account of the variation in contents and ratios of minerals in the dandelion. In an attempt to do this we compared corresponding samples of dandelion and grass, grown under identical, but quite variable conditions.

Since Kirchner (1955) states that the dandelion is almost ubiquitous, considerable variations in its contents and ratios of minerals can be expected. According to him dandelions occur with greatest frequency in grasslands having a high potassium content. Owing to considerable differences in fertility level caused by grazing cattle in one paddock (Van der Kley, 1955) dandelions might be expected to grow at higher mean levels of potassium than does the other herbage from the same plots. It is the aim of this paper to avoid bias from this source.

2. Material and methods

2.1. *Sampling and fertility of soils*

Possible bias from potassium and other sources has been avoided by cutting corresponding samples of dandelions and grass at the same time (15th–30th May 1955) and taking care to cut them at the same places. Thus the conditions under which both herbages were grown are expected to be identical, but different from the mean fertilities of the grassland plots sampled.

The mean values and ranges of the average fertilities of the whole paddocks shown in table 1 may, however give a rough idea of the variation obtained under experimental conditions.

Table 1 The ranges and mean values of the average contents of phosphorus and potassium and the mean pH's of the paddocks sampled.

Contents expressed as:	Moist sandy soil (n = 19)		Rhine clay soil (n = 15)		Extraction with:
	range	mean	range	mean	
mg P_2O_5/100 g dry soil	57–200	91	11–70	28	1 % citric acid
mg K_2O/10 g dry humus	10–47	29	15–32	21	0.1 N chloric acid
pH – KCl	4.6–6.4	5.7	4.5–6.6	5.2	1.0 N KCl solution

In the dandelion as well in the grass we found only a few differences in mineral contents between both types of soil which could not be explained by its crude protein contents (see 't Hart, 1945 and Brandsma, 1954).

2.2. *Preparation of results*

To obtain this considerable range of mean chemical fertilities we sampled in particular grassland plots with well-known, recently determined extreme mean soil analyses. Owing to this selection the contents of minerals in our herbage samples were not always normally distributed. No corrections have been made, so that the absolute values of standard deviations and correlation coefficients calculated are liable to error. This bias may be expected, however, to affect both crops and its minerals to the same degree.

For calculating regressions and equations we used the covariance method as described by Van Uven (1947), assuming y and x to be equally uncertain. In actual fact we found the percentages of crude protein and fibre in the silica-free dry matter of dandelions (y) corresponded to those in the grass (x). The resulting regression equations are:

1) expected % of crude protein : $y = 15.0 + 0.674\,(x - 18.3)$ $(r = 0.866)$,
2) „ % of fibre : $y = 16.9 + 1.773\,(x - 22.6)$ $(r = 0.760)$.

These regressions are shown graphically in figure 1. They have not been extrapolated from the original range of analyses.

Since it may be inferred from these regressions that grazing cattle keep dandelions and grass in comparable stages of maturity, we were able to compare the mineral contents of both crops without converting them to the same crude protein contents.

In order to illustrate the importance of our results for cattle-feeding and

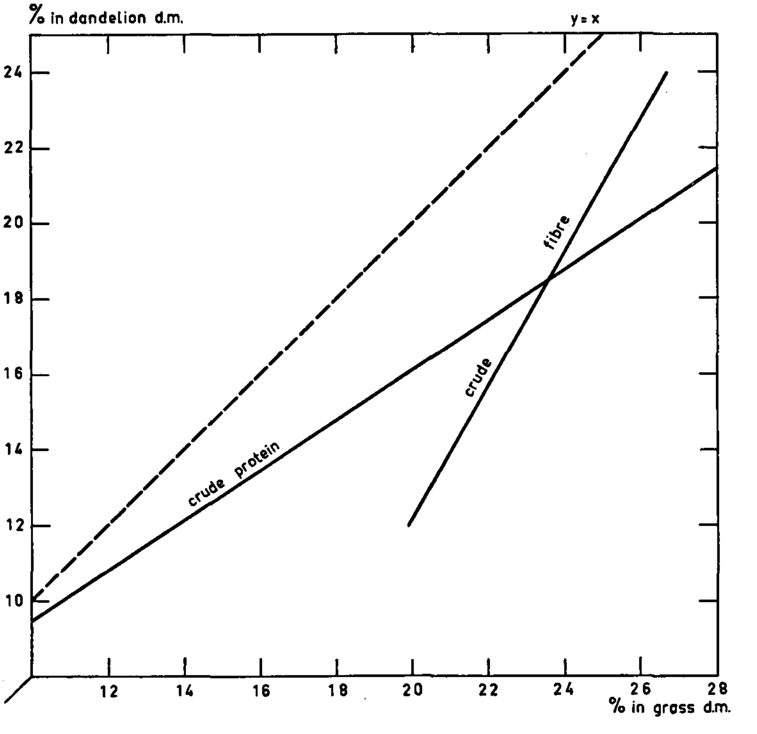

Fig. 1 The relation of the expected percentages of crude protein and fibre in the dry matter in dandelion to those in grass.

animal health we used the diagrams and symbols introduced by BROUWER and co-workers (1951–1954).

The samples of both crops were dried artificially at 105° C. Then they were taken to the Laboratory for Soil and Croptesting TNO, Oosterbeek. The methods of analysing the samples have been described by DE VRIES and DECHERING (1947).

3. RESULTS AND DISCUSSION

3.1. *Separate minerals*

Table 2 shows the mean values, ranges and coefficients of variation of the single contents of major elements in the two types of herbage dry matter. Column 8 gives the correlation coefficient (r_{xy}) of the separate contents in dandelion and grass.

Table 2 The mean values, ranges and coefficients of variation (cv) of the single contents of major elements in the silica-free dry matter and the correlation coefficients (r_{xy}) of these contents in dandelion (y) and grass (x).

Contents of:	Grass dry matter			Dandelion dry matter			r_{xy}
	mean	range	cv	mean	range	cv	
K_2O	3.88	2.87–4.94	13 %	4.20	2.79 –5.37	18 %	0.728
Na_2O	0.20	0.06–0.43	40 %	0.50	0.125–1.15	58 %	0.330
CaO	0.79	0.57–1.16	20 %	1.14	0.75 –1.61	18 %	0.276
MgO	0.27	0.16–0.41	19 %	0.39	0.29 –0.69	26 %	0.420
Cl	1.39	0.56–2.22	35 %	1.53	0.68 –2.38	32 %	0.680
P_2O_5	0.94	0.61–1.32	19 %	0.84	0.57 –1.17	18 %	0.838
SO_3	0.61	0.42–0.97	20 %	0.53	0.37 –1.10	25 %	0.497
N	2.94	1.80–4.62	19 %	2.40	1.52 –3.47	16 %	0.866

3.1.1. *Mean values and variations*

It can be seen from table 2 that the mean contents of kations and chlorine in dandelion are higher than in grass. The dandelion is poor in phosphorus, however, and has a lower mean sulphate content than grass.

The range of all kation contents is also higher in the dandelion. The ranges of chlorine content are about equal in both herbages and the ranges of phosphorus and sulfate contents are lowest in the dandelion.

The values of calcium and potassium shown in table 2, together with the crude protein contents in our dandelion are much smaller and the phosphorus contents only somewhat smaller than the corresponding figures published by KIRCHNER (1955). In actual fact, the soils in the neighbourhood of Stuttgart are supposed to be higher in Ca-content and pH than ours. As VAN SOEST (1939, 1952) describes 21 sub-species of Taraxacum which morphologically are very difficult to distinguish, KIRCHNER (1955) might have sampled other sub-species of dandelions than we did.

In the columns 4 and 7 of table 2 the calculated standard deviations of the single observations are expressed as percentages of the mean of these observations. Comparing columns 4 and 7 we conclude that the highest "relative variations" of the K, Na and Mg contents occur in the dandelion. For the contents of Ca, Cl and P the coefficients of variation are about equal in both types of herbage. The relative variation in sulphate content is highest in grass.

3.1.2. *Regressions*

In fig. 2 some contents of minerals in dandelion and in grass are compared graphically. It is suggested in fig. 2 that taking any given herbage content both crops diverged more as the levels of that particular content rose in each crop.

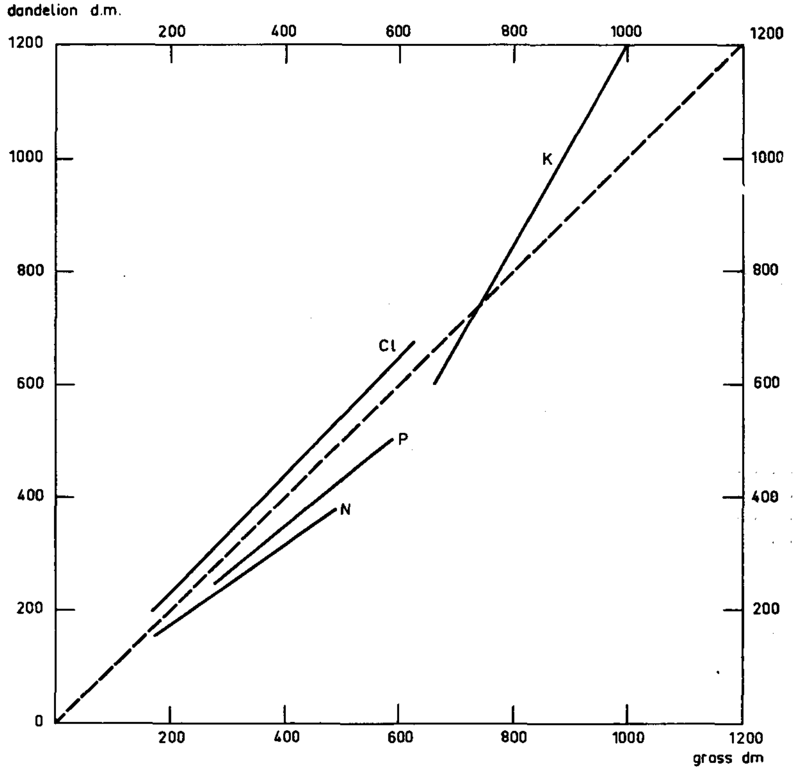

FIG. 2 THE RELATIONS OF THE EXPECTED CONTENTS OF N, P. K AND Cl OF DANDELION TO THOSE IN GRASS. The contents of P, K and Cl are expressed as milliequivalents per kg of dry matter; the N content as (percentages × 100) of the dry matter.

Because of its low correlation coefficients, shown in column 8 of table 2, no other lines than those shown in figure 2 were calculated. The regression equations corresponding to the lines of fig. 2 are:

1B) expected nitrogen-content $N_y = 2{,}40 + 0.674\ (N_x - 2{,}93)\,\%$; $r = 0{,}866$
3) „ phosphorus „ $P_y = 353 + 4.793\ (P_x - 398)$; $r = 0.838$ *)
4) „ potassium „ $K_y = 891 + 1.733\ (K_x - 823)$; $r = 0.728$
5) „ chlorine „ $Cl_y = 431 + 1.042\ (Cl_x - 391)$; $r = 0.680$.

3.2. *Base-forming elements*

The total base contents BT = K + Ca + Mg + Na of dandelion and grass were probably not correlated ($r_{xy} = 0.270$). For studying the ranges and mean

*) From this point onward we express all contents and figures of macro elements as milliequivalents per kilogram of silicafree dry matter (P = 3 eq.). In all regressions and correlations calculated we indicate the dandelion by y and the grass by x. From the T-table (n = 34) the following levels of significance were calculated:
$r^x = 0.3398$ (P = 0.95), $r^{xx} = 0.3976$ (P = 0.98) and $r^{xxx} = 0.4374$ (P = 0.99).

values of the component percentages of BT we therefore give these figures for each type of herbage separately. Table 3 shows them numerically together with their correlation-coefficients r_{xy}.

Table 3 Ranges, mean values and correlation coefficients of the component percentages in the aggregates BT = K + Ca + Mg + Na of dandelion (y) and grass (x).

Component	Dandelion		Grass		r_{xy}
	range	mean	range	mean	
% K	35–66	54.1	55–72	63.4	0.558
% Ca	17–31	24.5	17–30	21.5	0.325
% Mg	8–17	11.8	8–14	10.1	0.518
% Na	4.5–15.1	9.7	2.7–7.5	5.0	0.472

3.2.1. *Means and variations*

It is clear from table 3 that the mean percentages of Ca, Mg and Na are highest in the herb. This is also the case with the variations in the values of K and Na. The range in Ca% and Mg% is about equal in both types of herbage.

Table 5 (column 6) shows that the total base content of the dandelion is much higher than in grass. Its variation is however, about similar in both forages.

3.2.2. *Regressions*

The correlation coefficients shown in table 3 correspond to the following regression equations:

6) expected % K in BT : $\% K_y = 54.1 + 2.77\ (\% K - 63.4)$
7) „ % Ca „ : $\% Ca_y = 24.5 + 1.25\ (\% Ca_x - 21.5)$
8) „ % Mg „ : $\% Mg_y = 11.8 + 2.77\ (\% Mg_x - 10.1)$
9) „ % Na „ : $\% Na_y = 9.7 + 3.67\ (\% Na_x - 5.0)$.

These relations are shown in graph form in fig. 3. They should not be extrapolated as curvilinearity might occur.

It can be seen from fig. 3 that despite the lower mean potassium value in the dandelion its expected difference from grass decreases with rising K-levels. As to their Ca, Mg and Na-values, the herbages diverge less with decreasing component percentages.

3.2.3. *The base diagram*

These and other conclusions on the mutual relations of base-forming elements in feeding-stuffs may also be derived graphically from the regular tetrahedral base diagram (fig. 4), introduced and explained in detail by Brouwer (1951, 1952).

Unlike Brouwer and co-workers (1951–1953), for the sake of clarity we only showed the back of the tetrahedon in fig. 4. As a result the ratios K/Ca, K/Mg and K/Na are equal to 1 on the perpendiculars erected in the excentric 50 % points on these sides. The locus Ca/Mg = 1 is, however, shown by the perpendicular tearing of the side opposite.

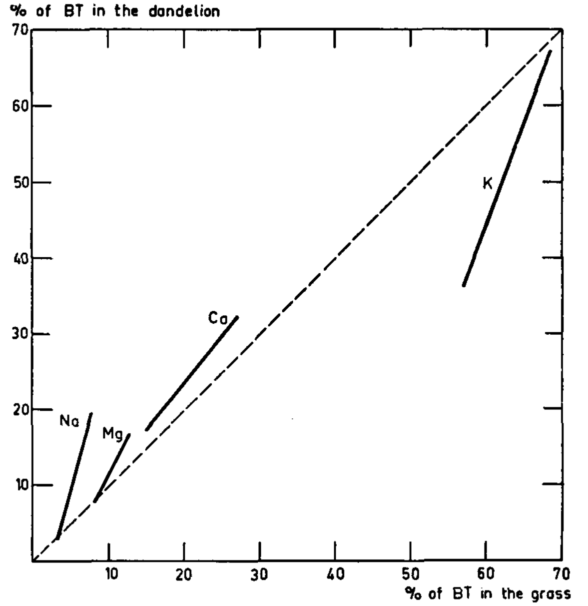

FIG. 3 THE RELATIONS OF THE COMPONENT PERCENTAGES OF THE BASE TOTAL BT IN THE DANDELION TO THOSE IN GRASS.

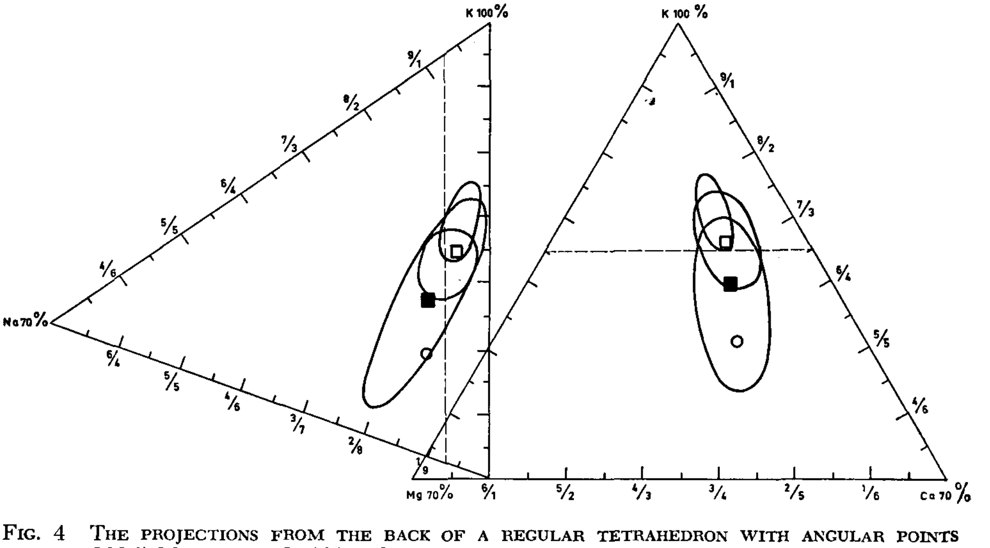

FIG. 4 THE PROJECTIONS FROM THE BACK OF A REGULAR TETRAHEDRON WITH ANGULAR POINTS 100 % Mg, 100 % K, 100 % Ca AND 100 % Na.
In the right-hand triangle (centrally projected from the vertex 100 % Na) the proportions of K, Ca and Mg can be read off as percentages of their aggregate $S_3 = K + Ca + Mg$ by making use of the scales of the triangle sides. In order to convert them into percentages of the base total $BT = K + Ca + Mg + Na$ they should be multiplied by $\frac{100 - Na}{100}$.
In the left-hand triangle (normal vertical projection) the percentages K and Na in BT can be read off directly with the aid of the scales on the triangle sides (cf. BROUWER, 1952).
In lower ovals: all samples of dandelion with mean ■.
In middle ovals: all samples of grass with mean □, except the separate circle.
The broken lines and upper ovals are discussed in section 4.1.

As will be clear from fig. 4, all ratios of the alkalimetals to Ca and Mg are most variable in the dandelion. The considerable range in its K and Na values suggests that the favourable exchange of K by Na occurs in Taraxacum to a higher extend than in grass.

The separate sample of grass ○ shown in fig. 4 has not been taken into account. Botanically this sample contained much Carex and other wet-indicating non-gramineous plants. We took the sample at an acid, poor riverclay soil, the mean figures of the paddock being: pH'KCl = 4.5; 17 mg P_2O_5/100 g dry soil; 18 mg K_2O/11.1 g dry humus.

3.3. *The acid-forming elements*

3.3.1. *Means and variations*

In table 4 we expressed the contents of separate acid-forming elements as component percentages of their aggregate ZT. Table 4 shows their ranges and mean values, together with the corresponding correlation coefficients.

Table 4 Ranges, mean values and correlation coefficients of the componentpercentages in the acid-totals ZT = P + Cl + S of dandelion (y) and grass (x).

Component	Dandelion		Grass		r_{xy}
	range	mean	range	mean	
% P	24–56	39.1	33–52	42.9	0.645
% Cl	29–65	45.8	28–55	40.6	0.762
% S	12–23	15.1	10–20	16.5	0.831

3.3.2. *Regressions*

The mutual relation of dandelion and grass as to its total acid contents ZT = Cl + S + P, is represented by the equation:

10) $ZT_y = 917 + 0.78\ (ZT_x - 940)$; $r_{xy} = 0.795$.

It is clear from equation (10) that the higher ZT-level rises, the more both herbages diverge. Despite the lower total N content (the most important acidoid) shown in equation (1) and the higher total base content discussed in the proceeding section as a rule we may expect the total acid content to be lowest in the dandelion.

Furthermore the correlationcoefficients shown in table 4 correspond to the following regression equations:

11) expected % P in ZT: $\%P_y = 39.1 + 1.91\ (P_x - 42.9)$

12) „ % Cl „ : $\%Cl_y = 45.8 + 1.49\ (Cl_x - 40.6)$

13) „ % S „ : $\%S_y = 15.1 + 0.94\ (S_x - 16.5)$.

These relations are shown graphically in fig. 5. It is clear from fig. 5 that the expected difference of the Cl-values in dandelion and grass increases as the Cl levels rise. Moreover the low P-values improve more easily in the dandelion than in grass.

In fact this suggests that in soils poor in phosphate content the dandelion cannot take up the mineral with the same rate as does grass, so that P is exchanged by Cl to the greatest extent in Taraxacum.

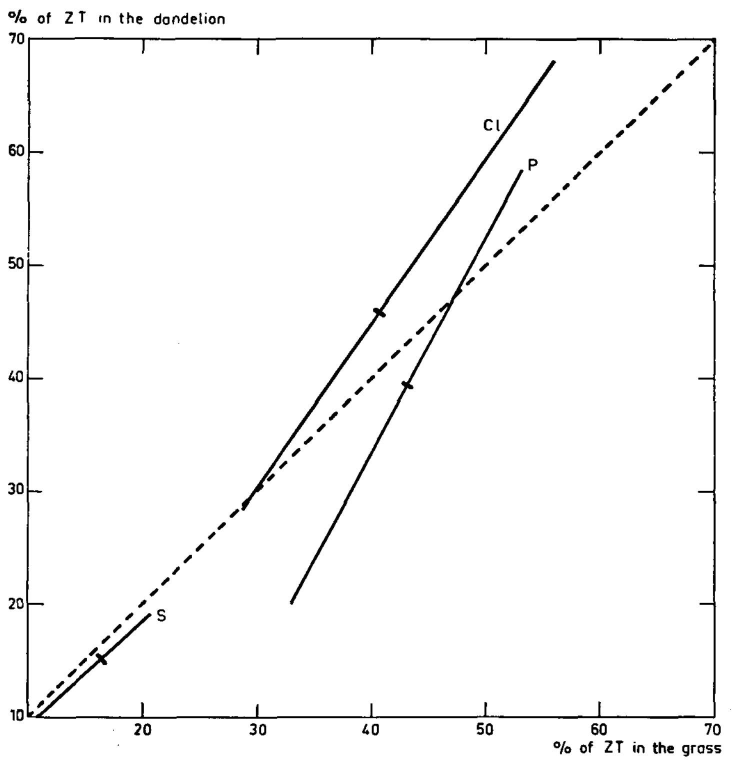

FIG. 5 THE RELATIONS OF THE COMPONENT PERCENTAGES OF THE ACID-TOTAL ZT IN THE DANDELION TO THOSE IN GRASS.

3.3.3. *The acid diagram*

These inferences can also be drawn from the acid diagram introduced by BROUWER (1951[2], 1952). In the diagram shown in fig. 6 the componentpercentages of ZT can be read off in the same way as in the right-hand part of fig. 1.

Moreover the ratios of every two acids are equal on every perpendicular drawn on the side between its 100% angular points in the triangle.

It will readily be seen from fig. 6 that the P/Cl and P/S ratios are most variable in herb and grass, this being a consequence of the mutual exchange of P by Cl in plant functions. These acid-exchanges are, however, far less considerable in extend than the exchanges between the base-forming elements.

The high percentages of sulphur in the samples in Fig. 2 indicated separately, might probably be explained by the peaty soil and the manuring of these plots. These samples have not been taken into account in columns 2 and 4 of table 5. Unlike other sampled grasslands these paddocks were regularly given high amounts of dung. It is interesting to note that the separate grass-circle corresponds to the upper dandelion sample.

3.4. *Acid-base relationships*

The relations between the total base (BT) and total acid (ZT) contents are represented by the equations:

14) $BT_y = 1651 + 1.03\ (ZT_y - 917)$; $r = 0.637$ (dandelion),

15) $BT_x = 1305 + 0.62\ (ZT_x - 940)$; $r = 0.748$ (grass).

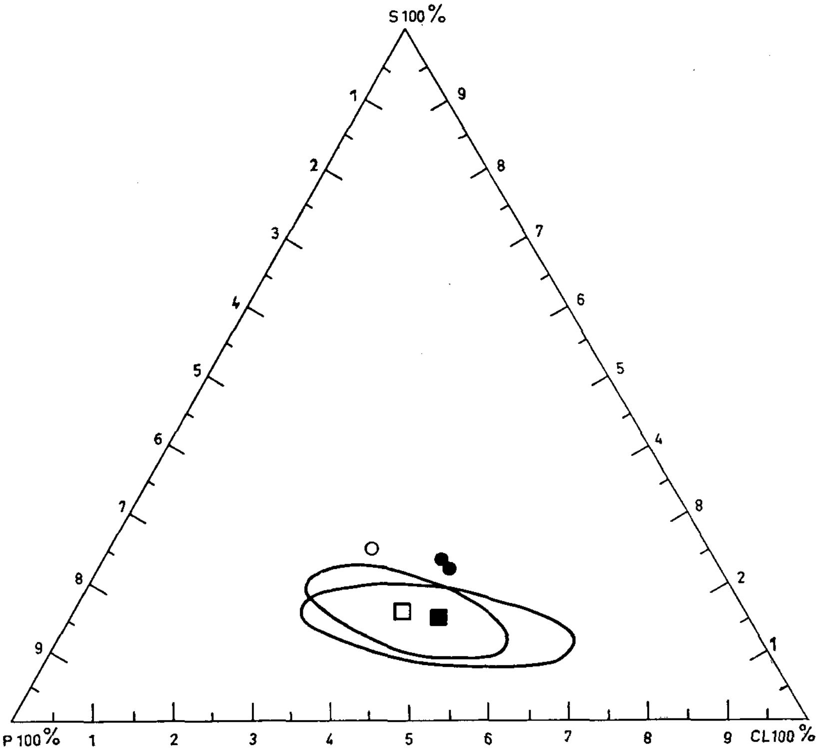

FIG. 6 TRIANGULAR ACID-DIAGRAM (P = 3 EQUIVALENTS). THE PROPORTIONS OF Cl, S AND P, EXPRESSED AS PERCENTAGES OF THEIR AGGREGATE ZT, CAN BE READ OFF FROM THE SCALES ON THE SIDES OF THE TRIANGE.
In the short oval: all samples of dandelion with mean □ except two dots.
In the long oval: all samples of grass with mean ■ except the circle.

The regression of the base excess VT = BT − ZT to ZT differs not significantly from zero in the herb. So it follows that VT is independent from ZT and, according to equation (14) to the total ash content TT = BT + ZT. On the other hand, in the grass the base excess decreases with an increase of TT. As a result the difference between the herbages are expected to be highest in plants with high ash contents, or, in fact in sampling young plants.

3.4.1. *The acid base diagram*

This can be seen in graph form in the acid base diagram (fig. 7) introduced by BROUWER et al. (1951, 1952).

It is clear from figure 7 that unlike the variations in TT, BT and ZT, practically all values of BT and VT together with their means, the mean TT and the range in VT are highest in the herb. These conclusions may also easily drawn from table 5 (columns 5 to 7). As to TT and VT their correlations in dandelion and grass (table 5) are brought about by the high correlation shown in equation (10).

3.4.2. *Alkalinity*

The physiological need to consider not only the total base excess VT = BT − ZT in feeding stuffs but also the base excesses of the mainly defecated elements Ca, Mg and P, and of the mainly urine-dissolved elements K, Na, Cl

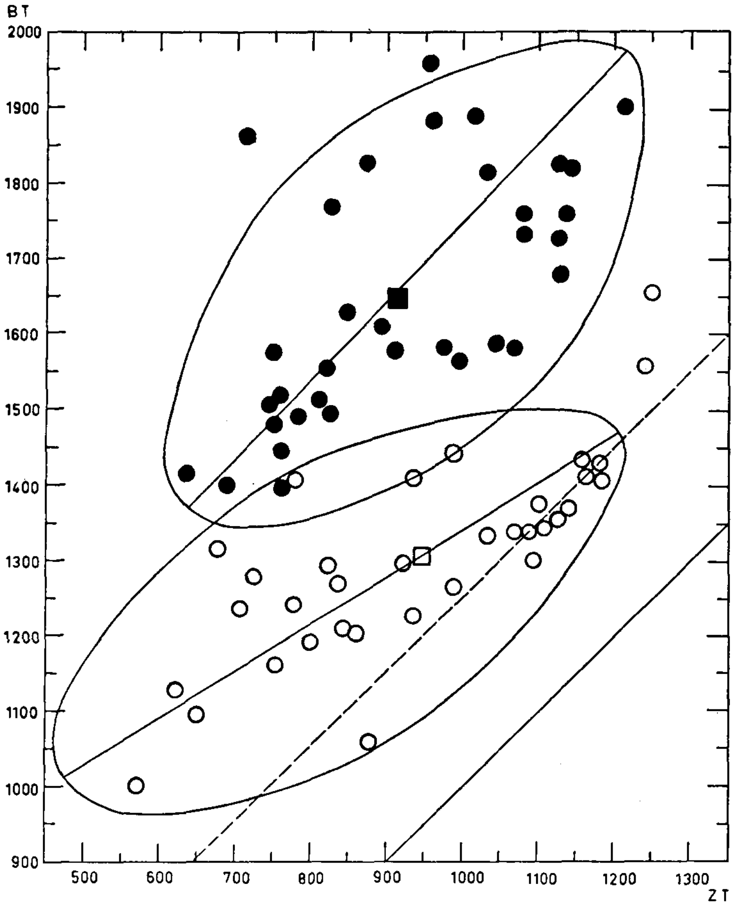

FIG. 7 ACID-BASE DIAGRAM. THE ABSCISSAE AND ORDINATES SHOW THE TOTAL CONTENTS OF ACIDS AND BASES RESPECTIVELY. If measured from the slanting line BT = ZT as zero base, the ordinates represent the base excesses VT = BT − ZT. The actual values TT = BT + ZT from any point shown in the figure can be best read off from the ordinate cut off the BT- or ZT-axis by a line with a gradient of −1 ($\varphi = 135°$) drawn through that point.
Dots and upper oval drawn by hand: samples of dandelion with regression line and mean ■.
Circles and lower oval drawn by hand: samples of grass with regression line and mean □.
The broken line will be discussed in section 4.1.

and S separately, has been shown by BROUWER et al. (1951, 1952). To facilitate this separation he introduced the alkalinity diagram shown in fig. 8. In this graph the alkaline earth alkalinity EA + Ca + Mg − P (P = 3 eq.) and the alkali alkalinity AA = K + Na − Cl − S have been plotted on the abscissae and ordinate respectively. As in fig. 7, their difference VA = AA − EA and aggregate TA = AA + EA can be measured in the figure. Clearly TA = VT.

It will be seen from fig. 8 that AA, EA and TA = VT are highest in the dandelion. VA is highest in the grass and is less variable here than in the dandelion. In the latter crop the TA and EA range is also highest. The varia-

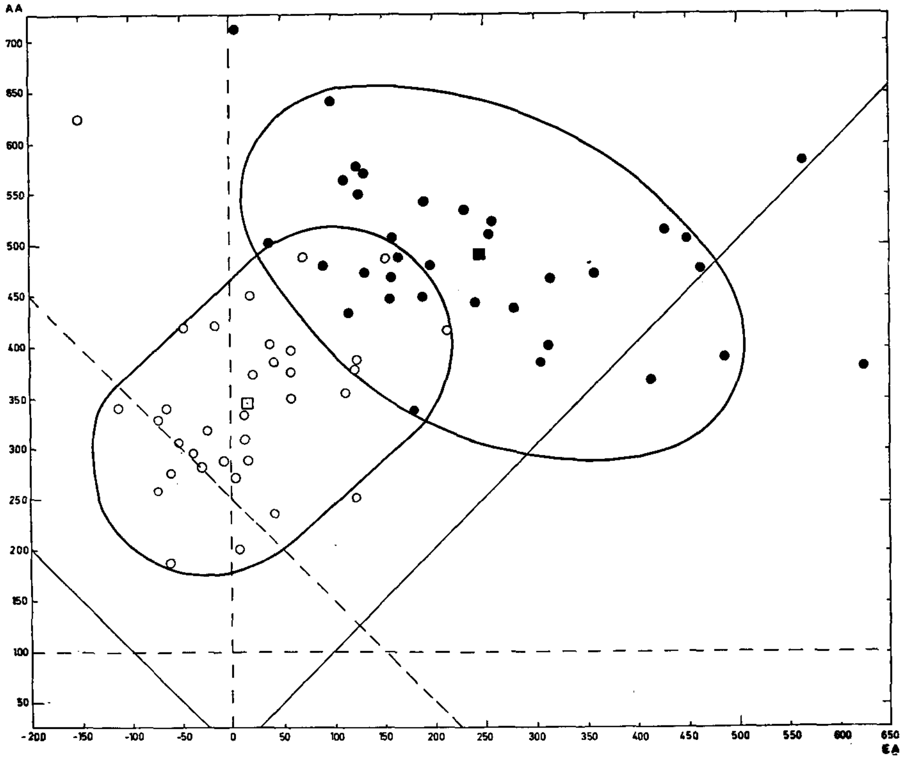

FIG. 8 ALKALINITY DIAGRAM (P = 3 EQ.). THE ABSCISSAE AND ORDINATES INDICATE THE BASE EXCESSES EA = Ca + Mg − P AND AA = K + Na − Cl − S RESPECTIVELY.
All contents are expressed as meq/kg silica-free dry matter.
Dots and upper oval: samples of dandelion with mean ■ .
Circles and left-hand oval: samples of grass with mean □ .
The broken lines are discussed in section 4.1.

tion of AA is about the same in both types of herbage. Readers who are more familiar with tables may draw these conclusions from table 5.

Table 5 Ranges, mean values and correlation coefficients of some alkalinities and aggregates in the dry matter of dandelions and grass.

Symbol	Dandelion		Grass		r_{xy}
	range	mean	range	mean	
AA	335–712	490	188–487	346	0.226
EA	7–626	247	−111–216	15	0.430
VA	−99–538	243	128–464	331	0.371
TA = VT	518–1004	737	185–640	361	0.513
BT	1398–1961	1651	1001–1655	1305	0.270
ZT	634–1214	917	567–1249	940	0.795
TT	2049–3117	2558	1568–2904	2245	0.577

In the ranges, shown in table 5 the points outside the ovals have not been taken into account. The separate samples in the upper left-hand belong together and were taken in a paddock extremely high in phosphorus (143 mg P_2O_5/100 g dry soil) and potassium (47 mg K_2O/10 g dry humus).

High contents of P and K in the herbage dry matter of these samples caused a low EA and high AA.

Comparatively speaking the samples of dandelion on the right were high in Ca and Mg content and normal in P, despite the normal average fertility levels of its plots. These paddocks were continually grazed, however, so that they may be expected to show a great lack of uniformity (VAN DER KLEY, 1955) as regards soil fertility. The upper sample in the figure was regularly manured with dung. This sample is also shown separately in fig. 2, also together with the corresponding grass.

It is clear from table 5 that the alkalinities do not show x-y correlations, the slight EA and TA x-y correlations being brought about by P and (K + P + Cl) respectively.

3.4.3. *The alkali alkalinity diagram*

Triangular and tetrahedral diagrams are used in order to explain the high variations in alkalinities in the preceeding section. Figure 9 represents the alkali alkalinity diagram introduced by BROUWER et al. (1953). This tetrahedron makes it possible to read off the proportions of the AA materials K, Na, Cl and S as percentages of their aggregates (K + Na + Cl) and (K + Na + Cl + S). This will be clear from the discussion of fig. 4.

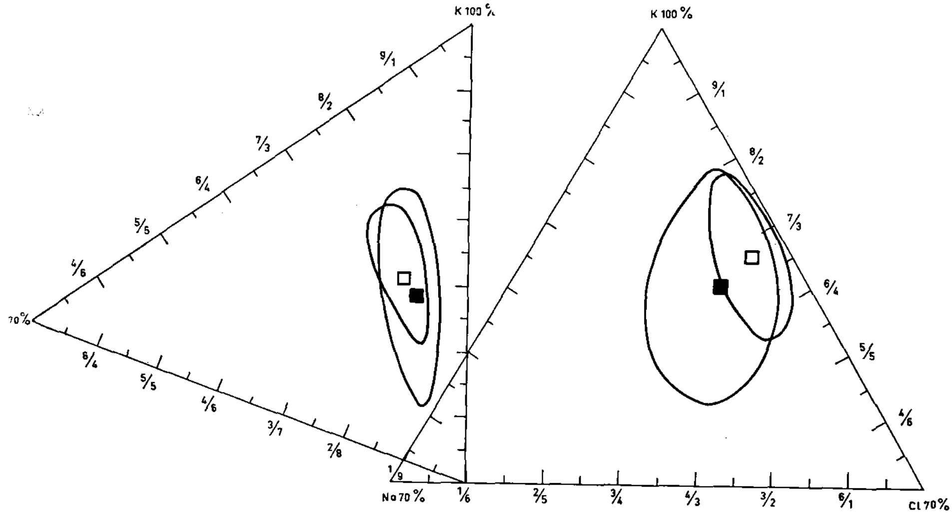

FIG. 9 NORMAL VERTICAL AND CENTRAL HORIZONTAL PROJECTIONS FROM THE VERTEX 100 % OF THE BACK OF A REGULAR TETRAHEDRON WITH ANGULAR POINTS 100 % Na, 100 % K, 100 % Cl AND 100 % S.
For further explanation see figure 4.
In large ovals: all samples of dandelion with mean ■.
In small ovals: all samples of grass with mean □.

It follows from fig. 9 that the maximum contribution made by potassium to (Na + K + Cl) is the same in both types of herbage, but the mean contribution of K is highest in the grass. As in fig. 4, the range and mean of the potassium percentages and the suggested substitution of K and Na are greatest in the dandelion. Indeed, the range and mean of the percentage of sodium is fairly high in the dandelion. The less variable percentage of S and its range are about the same in both types of herbage as is also the case with the more variable chlorine percentage. It is clear that the variations in the AA described in the preceeding section mainly originate in the fluctuations in the K values.

3.4.4. *The alkaline earth alkaline diagram*

Figure 10 shows the EA-constituting elements plotted in the triangular alkaline earth-alkaline diagram introduced by BROUWER et al. (1953).

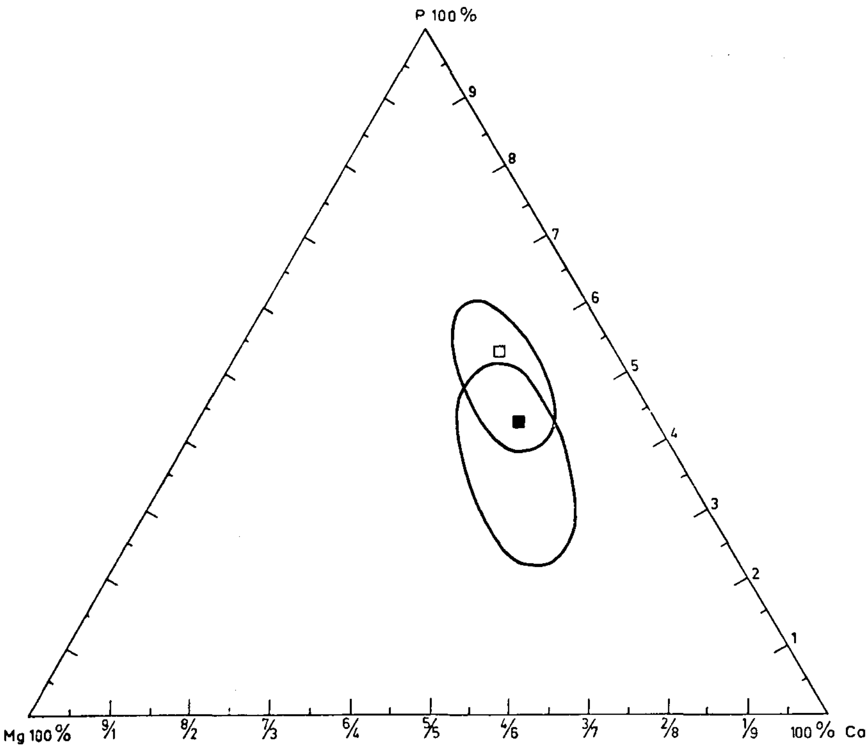

FIG. 10 TRIANGULAR EA DIAGRAM (P = 3 EQ.). THE PROPORTIONS OF THE EA-CONSTITUTING ELEMENTS Ca, Mg AND P, EXPRESSED AS PERCENTAGES OF THEIR AGGREGATE, CAN BE READ OFF FROM THE SCALES ON THE SIDES OF THE TRIANGLE.
In short oval: all samples of grass with mean □.
In long oval: all samples of dandelion with mean ■.

It can easily be seen from fig. 10 that in both types of herbages the ranges of P, Mg and Ca decrease in the order mentioned here. In fact the P value is prominent in the EA, although its position is less predominant than that of K in the AA. Obviously the higher EA in the dandelion is mainly due to lower P values, although the Ca and Mg percentages are somewhat higher in the dandelion than in the grass.

The conclusions mentioned here are shown numerically in table 6.

Table 6 Ranges, mean values and correlation coefficients of the component percentages in the AA and EA materials.

Aggregate	Component % of aggregate	Dandelion		Grass		r_{xy}
		range	mean	range	mean	
K + Na + Cl . . .	K %	42.85–78.0	60.50	52.70–76.40	65.11	0.178
	Na %	2.90–25.30	11.17	1.75–9.05	5.16	0.519
	Cl %	18.60–36.75	28.33	19.85–38.25	29.73	0.663
K + Na + Cl + S	S %	5.80–13.90	8.49	7.60–15.70	10.69	0.868
Ca + Mg + P . .	Ca %	31.80–54.75	40.10	26.85–41.70	33.01	0.337
	Mg %	14.40–29.10	17.43	10.20–21.45	14.78	0.642
	P %	23.00–49.65	42.47	39.45–59.05	52.4	0.645

It is clear from table 6 and figure 10 that unlike the ranges in the EA values, the high variations in the AA values in both crops (mainly in the dandelion) are caused by fluctuations in the kation percentages rather than in anion percentages.

4. Importance in cattle feeding and animal health

4.1. *Healthy herbage*

In the base diagram (fig. 4) we drew a small oval (the upper) containing six samples. These tetany-inducing samples of grass originally taken by Sjollema (1931) are fully discussed by Brouwer (1951). The samples lead to the assumption that low percentages of potassium and high sodium values in the base aggregates $S_3 = K + Ca + Mg$ and $BT = K + Ca + Mg + Na$ are important for the prevention of hypomagnesaemia in the cattle. The limited and out of date material discussed by Brouwer (1951) has been criticised by Temme (1953) of the Dutch Potash Company. More extensive investigations on the subject were recently carried out by 't Hart (1956 and in the press). His results agree with Brouwer (1951, 1952) and Sjollema (1931), but are not in agreement with Temme (1953).

Tentative limits of the alkalinities in healthy grass were published by Brouwer et al. (1951, 1952). In Brouwer's laboratory Brandsma (1954) checked these limits by describing extensively the analyses of 150 samples of herbage during the whole grazing season taken from 14 profitable "normal" "healthy" dairy-farms. By the latter are meant farms where the milk yield and the fertility of the animals are satisfactory and where metabolic diseases rarely occur. It is clear that Brandsma's figures (1954) may help us to evaluate the mineral pattern of forages. Moreover, although AA might be incidentally too high, it is generally accepted that in the Netherlands the alkalinities AA, EA and TA are often to low. Combining therefor the lowest mean values of AA, EA and TA in the average normal herbage of the whole season mentioned by Brandsma (1954) with 't Hart and Kemp's (1956) figures for grass expected to induce 3% tetany in cattle, we obtained the following theoretical characteristics of healthy grass:

% K in S_3	:	$<$ 65
% Na in BT	:	$>$ 7
TA	:	$>$ 250
AA	:	$>$ 100
EA	:	$>$ 0

The agglomerations of dots showing the relations of these characteristics in dandelions to those in the grass have been published elsewhere (VAN DER KLEY, 1956).

In the figures 4, 7 and 8 we indicated these theoretical characteristics by means of broken lines.

4.2. *Grass tetany*

As may be seen from figure 4, the mean base constellation of dandelion is expected to provide a better safeguard against tetany than the base constellation in the grass. Unfavourable samples of dandelion may also occur, however. Figure 3 suggests that the more tetany critical expected component percentages of K and Na in the grass, the smaller is the difference in the expected component percentages of dandelions and grass. This will be more clear from table 8.

Table 8 The expected difference between dandelions and grass with regard to K and Na component percentages in the total base contents BT.

Symbols in the forages	Potassium		Sodium	
	healthy herbage	critical herbage	healthy herbage	critical herbage
Component percentage of BT in grass	57	67	6.4	3.4
Expected value in BT of dandelions	36	64	15.0	4.0
Expected difference	+21	+3	−8.6	−0.6

Apart from the *expected* unfavourable mineral constellations of dandelions shown in table 8 the *actual* K and Na values exceeded the critical limits of grass-tetany in 10 out of 34 samples of dandelion. In fact, dandelions only afford a limited proof that herbage should not exceed the critical hypomagnesaemia limits of K and Na% in S_3 and BT.

4.3. *Acid urine*

Another aspect of the quality of herbage is shown in the figures 7 and 8. In practical grazing conditions we favour high values of AA and EA so as to prevent the possible occurrence of acid urine (see BROUWER et al., 1951) and perhaps grass-tetany respectively. The figures show that the alkalinities TA, AA and EA are expected to be more favourable in the dandelion than in the grass. In fact, the insufficient TA and EA occurring in various samples of grass discussed could have been improved by adding dandelions.

4.4. *Hypocupraemia*

Figure 11 shows the contents of copper in some samples of dandelions and grass. It is suggested that the copper content in the silica-free dry matter of dandelions is generally 2 parts per million higher than in the corresponding grass. As it has been shown by VAN DER GRIFT (1955) that the copper content in the blood and liver of 75% of Dutch cattle is probably to low, the high Cu-content of dandelions is considered favourable for preventing hypocupraemia.

WIND (1955) recently suggested that hypocupraemia will probably not occur in cattle if the copper content in the herbage dry matter is higher than approximately [3.8 – 0.02 (Ca – S – P meq/kg dm)] parts per million.

Figure 12 shows that the difference (Ca – S – P) is also most favourable in the samples of dandelions.

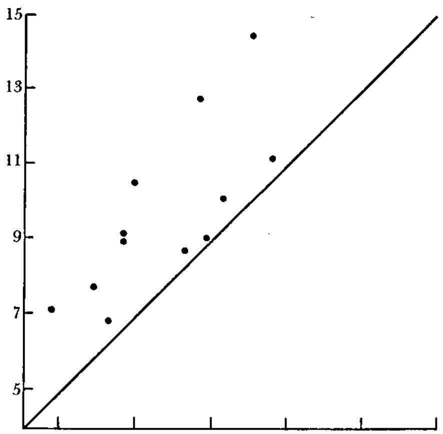

FIG. 11 THE COPPER CONTENTS (ppm) IN THE SILICA-FREE DRY MATTER OF SOME CORRESPONDING SAMPLES OF GRASS (abscis) AND DANDELION (ordinate).
(% SiO_2 in dandelion dry matter was 1.4 to 2.4, mean 1.57%; % SiO_2 in grass dry matter was 0.2 to 2.7, mean 1.14%).

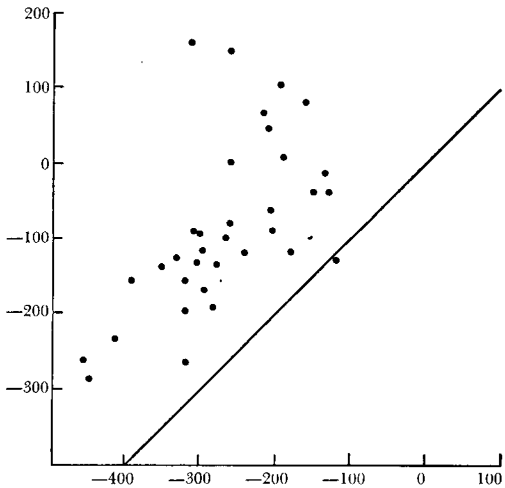

FIG. 12 THE (Ca – S – P) VALUES, EXPRESSED AS MEQ/KG DRY MATTER OF SOME CORRESPONDING SAMPLES OF GRASS (abscis) AND DANDELION (ordinate).

Consequently there are two reasons for concluding from fig. 11 and 12 that dandelions are a good antidote to scour and other forms of hypocupraemia in cattle. In actual fact, in dandelions and grass, respectively the mean *effective* Cu-contents were 180 and 110% of the amounts, according to WIND (1955) at least required. A third argument in favour of the dandelion might be its lower content of molybdenum. In two pairs of samples we found :

	Dandelion		Grass	
	sample 1	sample 2	sample 1	sample 2
ppm Mo in dry matter	0.2	0.2	0.8	0.5
% SiO_2 in dry matter	1.4	1.5	1.4	1.3

5. Conclusions

Taraxacum officinale is high in chlorine and copper and in all kations occuring in the herbage, but poor in phosphorus and sulphur. As a consequence its base excess TA, alkali alkalinity AA and alkaline earth alkalinity EA are higher than in the corresponding grass.

The sodium contents in the dandelion were fairly high, although very variable. Its variation in almost all mineral contents (mainly potassium), ratios of minerals (mainly K/Na) and alkalinities was higher than the corresponding ranges in the grass compared.

Owing, however, to the correlation of the elements, component percentages and alkalinities of the mineral constellations of both types of herbages occurring, a small percentage (15 to 20%) of the herb is expected to improve considerably the mineral constellation of samples of forage low in TA and AA and low in EA.

As to the component percentages of K and Na in the total base content dandelions are of limited importance as a safeguard against tetany in critical herbage. In general it is suggested that the balanced sward containing grasses together with 15 to 20% legumes and/or herbs is most desirable from the point of view of animal requirements for mineral constellations and minor elements in the forage. In particular the damage caused by acid urine, hamoglobinuria and hypocupraemia could be decreased by herbs to a considerable degree. We have shown elsewhere, (1956), however, that low yields, starch equivalents and contents of digestible protein actually lessen the agricultural value of dandelions.

Acknowledgments

It was possible to carry out the investigation reported thanks to a grant from the Mutual Security Administration. The author wishes to thank his Director Prof. M. L. 't Hart and also Dr. E. Brouwer, professor in animal physiology, for their constructive criticism. Moreover he is indebted to the District Officers of the Government Farm Advisory Services at Arnhem and Tiel, who procured the paddocks to be sampled, and to his assistent Mr. H. J. Kleter for careful sampling and aid in working up the results.

Last, but not least he is grateful to Dr. Brynmor Thomas and Dr. Alan Thompson, both of King's College, University of Durham, Newcastle-on-Tyne, and to the biometrican Mr. M. Keuls, Wageningen, for valuable suggestions in preparing the manuscript.

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