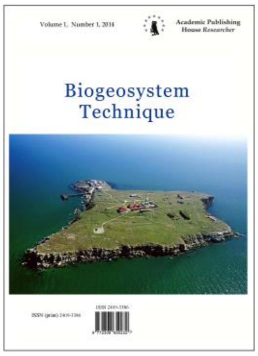


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**Elements in Rye and Wheat at Different Times and Different Places (Review)**

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**Abstract**

Grains constitute an important part of our daily food. And grains are also an important source of our daily magnesium supply. Especially wheat in the western countries. But the amount of magnesium in wheat has gone down dramatically with on average 19,6 %, as the data of Guo have shown. This has among others to do with soils, varieties and fertilizing. In this article the focus is on fertilizing. How can we change fertilizing in order to get better and healthier grains? Here is made a comparison between conventional fertilizing, and fertilizing with extra seaweed and other sea minerals, or with rock flour, or silt. The available data make clear that the type of fertilizer makes a big difference.

The data on Non Protein Nitrogen (NPN) are missing because they are not available in the historical records, nor in most actual analyses. High levels of NPN (a.o. nitrate; ammonium; nitrogen dioxide) are a serious health risk. The grains with conventional fertilizing are no longer in balance. Sodium has gone down dramatically. And from trials with ryegrass we know that extra sodium helps to restore the balance between the macro elements. Calcium in most grains is low, but the balance of Ca/P in the wheat from Normandy is much higher (= better) than in the other grains. And the Ca/P on silted soils is even better than on soils fertilized with seaweed and seaminerals as in Normandy.

Not only the grains and the potatoes from Normandy are more in balance, even the dung of the cows shows a somewhat healthier balance than modern cow dung. But here we can't draw conclusions yet, because the data from different eras and places are not really comparable.

With a good quality of vermicompost the balance in crops can be restored also. But here the rule is that the feeding material for the worms is decisive.

Magnesium is very important for human health. The first Homo's Sapienses are found in areas where the soil is very high in magnesium. This magnesium is erupted there bij earth mantle volcanoes. Many important food crops also originated in these magnesium rich centers of origin. But others came from fault lines which originated from colliding earth crust plates which have a granitic origin.

**Keywords**: magnesium, wheat, rye, potatoes, silt, seaweed, fertilizing in other ways, macro elements and their balance, animal dung, centers of origin.

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## 1. Introduction

Grains constitute an important part of human nutrition. And there is done a lot of research in order to improve the quality of the grains we use to eat: wheat; rice; oats, rye, maize, sorghum, millet and other.

But most food scientists have in my opinion no idea about the necessity of balances. They look at proteins and vitamins, and warn sometimes against empty foods which lack minerals and trace elements* (but mostly with a very soft voice…). Only a few scientists like White and Broadley in the UK (White, 2005) and Rosanoff (2013) in the USA look at the amount of magnesium, which has gone down dramatically in our daily food. But even White and his colleagues don't look at the general picture of the minerals and their balance, and the underlying system of fertilizing. And they ignore, or, more probably, dont know about the results of the balance studies, which are done mostly with dairy cattle. And much less for human beings.

Cattle cost money when they become ill. Human beings bring profits for the medical industry if they get ill. That is the reality in which sciences operate. Many scientists are no more independent. Governments in the west push them to get their funding from the industry.

And most food scientists don't know anything about fertilizing.

In the Dutch food supply wheat is the most important source of magnesium. And maybe rye could get a more prominent place also, if its quality goes up. In Wageningen we grow at the moment a special old variety of rye – St Jans Rye. This rye gives a special taste to the bread. In order to get a better idea about the quality, I have collected data about the balances in wheat and rye. For the Netherlands I couldn't find data for the whole grains, only for the breads and flours, brans and germs (see Annex 3).

The data on Non Protein Nitrogen (NPN) are missing because they are not available in the historical records, nor in most actual analyses. High levels of NPN (a.o. nitrate; ammonium; nitrogen dioxide) are a serious health risk (Visser, 2010).

So I used data from other countries and at different times, in order to find out about the different balances which were existing in the past and are existing at the moment in rye and wheat. And which are possible. My conclusion is that by fertilizing with NPK salts and with most animal dungs the balance has been distorted and the quality has gone down. And from the past we can learn that a.o. sodium for the graminaeae helps to improve the quality by restoring the balance. Sodium fertilzing is a real art. Too little doesn't work, too much is damaging. The same for seaweed and brine as extra fertilizers.

## 2. Results

### Fertilizing to restore the balance

Recently, the restoration of the balance has been confirmed by fertilizng with sodiumchloride on grassland. Sodium helps to lower the amount of potassium and at the same time to heighten the amount of sodium, calcium and magnesium in the rye grass (Chiy, Phillips, 1995). The role of sodium in plant growth is underestimated. But kitchen salt is not always a good fertilizer for improving quality of soil or food. Many crops don't grow well on NaCl-salt. There are better ways to rebalance our crops. In the books of Marchand I couldn't find data for rye. Maybe in other publications of that era we can still find them (Table 1).

**Table 1**. The data on macro-elements in rye and wheat

| Element | Rye | | | | wheat | | | |
|---|---|---|---|---|---|---|---|---|
| | USA (USDA database, 2017) | Poland (Kowieska, 2011) | UK (McCance, 1945) | Western Europe (Wolff, 1871) Ash, % | USA (USDA database, 2017) | Poland (Kowieska, 2011) | UK (McCance, 1945) | Normandy, red wheat (Marchand, 1869) Ash, % |
| Ca | 24 | 44 | 31.5 | 0.39 | 29 | 44 | 27.6 | 0.99 |
| Mg | 110 | 98.7 | 92 | 1.44 | 126 | 116.5 | 141 | 1.89 |
| P | 332 | 371 | 359 | 4.2 | 288 | 512 | 350 | 2.8 |
| K | 510 | 469 | 412 | 5.46 | 363 | 268 | 312 | 3.13 |
| Na | 2 | 28.1 | – | 0.27 | 2 | 11 | 3.2 | 2 |
| Total | 978 | 1010.8 | 894 | – | 808 | 951.5 | 833 | – |

* The work of Shridhar et al is a good example (Shridhar et al., 2015).

From an article in the Journal of the royal agricultural society it is clear that rye was also grown in Normandy (Taunton, 1846).

Now we can calculate the ratios for rye and wheat (Tables 2, 3):

**Table 2.** Ratios in Rye

| Ratios | Optimal ratios for human and animal food, feed/day | USDA, 2017 | Kowieska, 2011 | McCance and Widdowson, 1945 | Wolff, 1871 |
|---|---|---|---|---|---|
| K/Na | 1–4 | 255 | 16.6 | - | 20.2 |
| K/Mg | 2–5 | 4.6 | 4.75 | 4.47 | 3.79 |
| Ca/Mg | 1–2 | 0.22 | 0.44 | 0.34 | 0.27 |
| Ca/P | 1–2 | 0.07 | 0.12 | 0.09 | 0.09 |
| Mg/(K+Na+Ca+P) | 0.15–0.25 minimum 0.10 | 0.13 | 0.11 | 0.11* | 0.14 |

- USDA rye is almost complete without sodium, and the highest in magnesium and potassium;
- Poland rye is not bad for K/Na, in balance for K/Mg but not for calcium/magnesium and calcium/phosphor. Poland soils are poor in magnesium;
- Poland rye has the highest nutrient density (Wolff excluded);
- Potassium is the highest in the USA rye (Wolff excluded);
- Wolff rye has the highest Mg/(K+Na+Ca+P);

**Table 3**. Ratios in wheat

| Ratios | Optimal ratios for human food and animal feed/day | USDA, 2017 | Kowieska, 2011 | McCance, 1945 | Marchand, 1869 |
|---|---|---|---|---|---|
| K/Na | 1–4 | 181.5 | 24.4 | 97.5 | 1.6 |
| K/Mg | 2–5 | 2.88 | 2.3 | 2.2 | 1.66 |
| Ca/Mg | 1–2 | 0.23 | 0.2 | 0.19 | 0.52 |
| Ca/P | 1–2 | 0.10 | 0.08 | 0.08 | 0.32 |
| Mg/(K+Na+Ca+P) | 0.15–0.25 (Minimum 0.10) | 0.18 | 0.14 | 0.20 | 0.21 |

- USDA wheat is almost complete without sodium;
- USDA wheat is the highest in potassium (but sodium can help to bring down potassium in the USA wheat†);
- UK wheat is the highest in magnesium (Marchand excluded);
- Poland wheat has the highest nutrient density through very high P (Marchand excluded);
- The best wheat, in terms of the balances, was grown in Normandy, France in 1869. The reason: a different kind of fertilizing: guano dung, a good quality cow dung, brine and seaweed etc.

All grains have a low Ca/P ratio, but the least in the wheat from Normandy (Marchand, 1869). So extra calcium in the grains is possible (and necessary). By a better uptake of calcium Ca/Mg becomes also in a better balance.

Many other products in Normandy at that time, 1850–1881, were fairly well balanced: vetch; peas; carrots; milk; potatoes; white and black oats etc. At least compared to most other products in Western Europe in that period. (But not all: in Belgium they grew a nicely balanced white carrot (Wolff, 1871). My impression is that it is not the guano dung but the brine and seaweed which made the difference. Many other crops in Europe in that period were fertilized by guano dung, but without being in balance (Wolff, 1871). Maybe the trace elements plus sodium in brine and seaweed made the diference.

* Corrected for sodium, which was missing in McCance, 1945.

† In Hindi wheat from Egypt the K/Na was 10.45. This wheat was, according to Schrumpf Pierron, “the best wheat of Egypt” (Schrumpf Pierron, 1939). Only its calcium was too low.

Corollary

The quality of grains can be improved by better fertilizing practises. Levels for sodium, calcium and magnesium are part of this improvement. Guano dung is rich in sodium nitrate, and seaweed is rich in sodium, calcium and magnesium and many other elements, including trace elements (see annex 2). The same for brine. I didn't find information about the amounts of brine which were used in Normandy in the 19th century. According to Marchand the brine was also used as a fertilizer in the Norman agriculture.

From field trials in Wales, UK (Chiy, Phillips, 1995) we know that the balance in ryegrass is almost completely restored for potassium, calcium, magnesium and sodium by giving extra salt (optimum at the Wales soil ad 175 kg NaCl/ha) to the grass. The cows are fond of this salted ryegrass. But other grasses like timothy don't take up sodium as in ryegrass (Huhtanen et al., 2000). Many crops don't tolerate NaCl.

But from the trials of Wolff in 1849 and 1850 (cited by Strumpf, 1853: 42–56) we learn that high amounts of kitchen salt* (with an optimum at 1200 kg/ha) give good results for oats, and for barley. But not for buckwheat.

"Während bei dem Buchweizen schon geringe Mengen ([Kochsalz] schädlich einwirken, können bei Halmfrüchten, bei der Gerste wie bei dem Hafer sehr beträchtliche Mengen nicht allein ohne Nachtheil, sondern sogar mit grossen Nutzen verwendet werden" (Strumpf†, 1853: 50).

Small amounts of kitchen salt were also positive for wheat, but too much of it lowered the yields.

So how to fertilize?

Here I compare the cow dung from Normandy with the cow dung today in the Netherlands and Belgium (Table 4). Is the cow dung in Normandy (Marchand, 1881), like the crops, also more in balance than the modern Dutch and Belgian cow dung?

**Table 4.** Elements in different cow dungs

| G/kg fresh weight (fw) in manure | Norman manure (Marchand, 1881) | Belgian manure (Coppens, 2009) | Dutch manure (average of (Nutrinorm, 2016 and CBGV, 2012) | The average of belgian and dutch manure | The average of dutch slurry |
|---|---|---|---|---|---|
| K | 3.11 | 6.7 | 6.18 | 6.44 | 4.8 |
| Na | 0.85 | 0.74 | 0.77 | 0.75 | 0.51 |
| Ca | 3.98 | 3.57 | 2.84 | 3.2 | 2.8 |
| Mg | 1.44 | 1.0 | 1.89 | 1.44 | 0.72 |
| P | 0.78 | 1.72 | 1.52 | 1.62 | 0.6 |
| $N_{tot}$ | 4 | 8.5. | 6.5 | 7.5 | 4.1 |

The cow dung in Normandy was probably influenced by the seaweed and brine fertilization by the Norman farmers, through the fodders the animals ate (Table 5).

**Table 5.** Ratios in different animal dungs

| Ratios | Optimal ratio's for human and animal, food/day | Manure from Normandy (1881 or before) (Marchand, 1881) | The average of Belgian and Dutch manure (Nutrinorm) (CBGV) (Coppens, 2009) | Dutch slurry CBGV |
|---|---|---|---|---|
| K/Na | 1–4 | 3.65 | 8.58 | 9.4 |
| K/Mg | 2–5 | 2.15 | 4.47 | 6.6 |
| Ca/Mg | 1–2 | 2.76 | 2.2 | 3.88 |
| Ca/P | 1–2 | 5.1 | 1.9 | 4.6 |
| Mg/(K+Na+ Ca+P) | 0.15–0.25 Minimum 0.10 | 0.165 | 0.12 | 0.08 |

* From the tekst it is not clear if this salt is seasalt or salt from salt mines.
† Strumpf cited the results of Wolff from (Wolff, 1851).

In the Norman cow dung only the Ca/P is too high.

Can we draw further conclusions on the basis of this comparison?

At first sight we can think that the dung from Normandy on average seems better in terms of balances.

But now the complications:

- The dung from Normandy is a "Fumier de qualité moyenne" (Marchand, 1881). Literally, "a dung of average quality". But is the dung taken from a dung heap in which also straw was added, or is it pure dung? That means urine ánd shit? Or has part of the urine leaked away into the soil of the stable, or away from the manure heap? I suppose there were no concrete floors or basements. And was it cow dung or mixed dung form different animals? Was it fresh or old?
- And also the modern dung is not defined carefully. Is column 4 in Table 5 'shit plus urine plus straw', or only 'shit plus urine? And have the samples been taken when the material was fresh or after some months from for instance a manure pile?
- A further complication is that the animals in modern agriculture get a lot of supplements in order to balance the feed: salt; calcium carbonate and magnesiumoxide (and trace elements). We know that part of these supplements go straight into the shit like the magnesiumoxide which is taken up badly by the animals. Some vets say only 4 % is taken up. And also calcium carbonate is only taken up partly. High levels of potassium block the uptake of magnesium and calcium.
- And the dry matter contents of the samples differ;

So in fact conclusions are impossible.

So I decided to compare the Norman dung with the dung from other parts of Europe in the same era: 1850–1880. But Wolff (1871) provides no data on dung. The data in (Strumpf, 1853) are not usable because he gives them as alkalis (potassium and sodium together, and as calcium and magnesium earth (kohlensaurer Kalk und Bittererde) together, plus phosphoric acid – ammonia – magnesiumoxide (phosphorsaurer Ammoniak Bittererde). And also in the Journal of the royal agricultural society of England I couldn't find them.

For the health and the quality the differences in the manures are far-reaching. Already in 1933 Theel noted that potassium, sulphur and chloride had almost doubled in the German hays since 1881 (Theel, 1933). And Arzet demonstrated that in fodder this upward trend for potassium continued, while magnesium went down since 1910 (Arzet, 1972).

So now we have to investigate how we have to fertilize in order to balance the elements in our crops, avoiding the problems of fertilizing with high amounts of NaCl salt, and too much NPK.

Complete seaminerals* we can use as foliar fertilizer, strongly diluted. So we can avoid adding hughe amounts of salt(s) in the soil. And we can also use seaminerals with almost no NaCl. In the Netherlands these sodium poor seasalts are imported a.o. from Australia and the USA.

But that's one step. Schreiner has made clear that plants grow better on organic constituents than on inorganic salts:

"*I am ready to formulate the theory that these degradation products of protein [from plant residuals, N.] are absorbed by the plant directly from the soil and that the plant uses these units for building up the complex proteins as far as it is possible to do so. Nitrate is usually considered as the best form of nitrogen for plant food. In order to use nitrate, a highly oxidized form of nitrogen, to form the amido and imido*† *groups of the protein molecules, a reduction must take place. It is obvious that the plant must expend considerable energy in making this transformation. What is more reasonable than to suppose that the unit parts of the complex protein molecules, when presented to the plant, will be used by it in preference to preparing these units from the nitrate* "? (Schreiner, 1913).

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* Seaminerals are all the minerals and trace elements in seawater. In a good quality seaminerals there are 85 tot 90 elements available. Murray and Don Jansen in the USA have done a lot of research in fertilizing with seaminerals (Murray, 2003). Grains fertilized with seaminerals repressed cancer in cancer-mice for 100 %. (Voss, 2010).

† In organic chemistry, an imide is a functional group consisting of two acyl groups bound to nitrogen. These compounds are structurally related to acid anhydrides, although imides are less reactive (Imides, 2009; Sperry, 2011)

In 1957 Krasil'nikov formulated a comparable view when he stated that all metals are bound to organic compounds by microbes before being taken up by the plant roots* (Krasil'nikov, 1958, part III, p. 69).

And vermicomposts† offer a new opportunity to give these organic constituents to the plants, and to rebalance our crops. Vermicomposts contain high amounts of rhizosphere friendly microbes (Pathma, 2012) and of humic and fulvic acids – the ideal 'storage boxes' for nutrients. The plants can take the nutrients from the 'box' in a selective way with the help of rhizosphere microbes. And the soil microbes themselves break down in amino acids – a better nitrogen source than nitrate and ammonia (Schreiner, 1912). According to Geosol from Bursa in Turkey, plants fertilized by vermicompost contain no nitrate (Geosol, 2018) or, according to Pathma, less nitrate (Pathma, Sakthivel, 2012):

"Properties of vermicompost: (..) Nitrate residues are not found in plants grown with vermicompost. (..) [VC] gives the nutrients to the plant gradually based on the needs of the plant". (Geosol, 2018).

And when the bacteria break down in smaller units (viroids; nanobacteria; L. forms and other), the plants can take up these smaller units too. They act as their vitalizers (Rusch, 1968). The breakdown is probably facilitated by the bacteriophages on the slimey surfaces of the root tops (Barr, 2013). These bacteriophages protect the plants against invading bacteria, en help the plants by providing them with the tiniest vitalizing microbes.

Reading again the list of ryes in Wolff (Wolff, 1871: 14 Rye nr 3‡) I found another very interesting result: rye and oats which were fertilized with silt [reichlicher Schlammdüngung (kunstliche Überschwemmung)]. See annex 1 for a short introduction by Herapath (1850). This fertilizing is comparable with that with rock flour. This was the result for grains (Table 6).

**Table 6**. Elements in different grains grown on silted land

| Element | Rye on silt (UK)<br>Ash % | Oats 1. on silt (UK) [Fluss-schlamm]<br>Ash % | Oats 2. (after oats 1.) (UK)<br>Ash % | Wheat nr 1 (First sowing after broad beans, after flooding with silt§ (UK)<br>Ash % |
|---|---|---|---|---|
| Ca | 8 | 2.96 | 4.8 | 0.96 |
| Mg | 7.8 | 5.6 | 4.6 | 7.75 |
| P | 14.4 | 7.6 | 4.2 | 20.9 |
| K | 13.8 | 10.9 | 8.1 | 16.6 |
| Na | 13.6 | 6 | 4 | 11.7 |
| Pure ash | 2.65 | 3.95 | 3.06 | 2.3 (in dried seeds) |

The silt-rye was grown immediately after flooding with silt: "nach reichlicher Schlammdüngung" (Wolff, 1871: 14).

The oats were grown in this sequence: after flooding the land and giving the silt the first crop was broad beans, then three times wheat, then two times oats (Wolff 1871: 24). So the effect of the silt was the least for the last oats crop. But I must say, the farmers in this area brought huge amounts of silt on their land: sometimes two to three feet by repeated flooding with silt rich river water (Herapath, 1850). Here are the ratios (Table 7).

* "These observations showed that plants evidently take up iron, not in the form of mineral compounds, but in the form of organomineral substances formed under the influence of microorganisms". Also the other metals are complexed with organic compounds according to Krasil'nikov.

† Sinha has given a good overview about the qualities of vermicompost (Sinha, 2009).

‡ Wolff took these data from Liebig and Kopp "Jahresberichten f 1850 Tab A". Published by Th. J. Herapath. Herapath wrote about trials in Bristol with silt fertilizing (Herapath, 1850. Part I, p. 93; Part II pp. 500-536).

§ Strumpf, 1853: 121.

**Table 7**. Ratios in different grains grown on silted land

| Element | Optimal ratio's for human and animal food, feed/day | Ratios in the rye on silt | Ratios in the oats nr 1 on silt | Ratios in the oats nr 2 on silt | Ratios in wheat nr 1 on silt |
|---|---|---|---|---|---|
| K/Na | 1–4 | 1.01 | 1.8 | 2 | 1.41 |
| K/Mg | 2–5 | 1.76 | 1.9 | 1.8 | 2.14 |
| Ca/Mg | 1–2 | 1.02 | 0.52 | 1.04 | 0.12 |
| Ca/P | 1–2 | 0.55 | 0.39 | 1.14 | 0.045 |
| Mg/(K+Na+Ca+P) | 0.15–0.25 Minimum 0.10 | 0.155 | 0.20 | 0.27 | 0.155 |

And the percentage pure ash was for the silt-rye the second highest of 23 samples from different countries and soils: 2,65 % (Wolff, 1871: 14, 15).

Oats nr 1 of Herapath (fertilized with silt) and the white oats of Marchand had the highest ash content of all 25 oats in Wolff (Wolff, 1871: 24, 25).

From the list of ryes in Wolff we can also see that the amount of P in the rye on silt is the second lowest of the 23 ryes which were analysed. Maybe the mycorrhiza's were not yet present in the fresh silt.

This silt – rye is optimal for all ratios except for Ca/P. But this Ca/P – 0.55 – is even much higher than the best Ca/P of Marchand wheat: 0,32.

And we can also learn from it that the amount of calcium in grains can be much higher than the 'normal' amount. A question is if phosphor is not too low in the silt rye.The Nile silt gives very high amounts of P in Hindi wheat, and low amounts of calcium (Schrumpf Pierron, 1939). Ca/P in Hindi wheat is 0.153. The silt from the Nile is basaltic silt. The silt in Bristol where the silt rye was grown, was problably not a basaltic silt, but a more granitic silt.

Oats nr. 2 has the perfect balance. Only the ash content had gone down with 22 %.

Wheat nr 1 has one problem: a very low calcium content.

And we have to find out how much phosphor in our crops is really needed and healthy. In many wheat varieties phoshor is really very high, while sulphur is almost completely missing (Thomas, 1846). We don't know if phosphor is high because sulphur in the soils is low. According to the charts of Mulder there is no relation between the levels of sulphur in the soils and the uptake of phosphor. High magnesium levels stimulate high phosphor in the plants. Only high levels of zinc and of molybdenum oppose the uptake of sulphur.

And:

In a study on food from India the following amounts for elements in rye are mentioned:

- Potassium: 45
- Calcium: 61;
- Magnesium: 155;
- Other macro elements are missing.

If these data are correct, then rye can be an excellent source of magnesium (Manay, 2008).

### A comparison with potatoes

For potatoes I found a comparable result for fertilizing with rock flour (Table 8, column 5).

Hensel (1894) gave (granitic?*) rock flour on a potato field in Pommeren in 1890. I compare them with the ratios in nowadays Dutch potatoes and in potatoes from Normandy 1864. These are the results (Table 8).

* Normally Hensel worked with granitic rock flours (Hensel, 1894).

**Table 8**. Ratios in potatoes with different fertilizing systems

| Element | Optimal ratio's for human and animal food/day (Nigten, 2018) | Potato trial of the Louis Bolk institution. The average of thirteen different fertilizings. (Burgt et al., 2012) The Netherlands. | Three potato varieties Parmen-tier, Patraques en Vitelottes in Normandy (Marchand, 1866). The potatoes were fertilized with guano fertilizer, seaweed and animal dung*. | | | | Potatoes in Pommeren (Hensel, 1894)†, fertilized with rock flour. By Hensel. |
|---|---|---|---|---|---|---|---|
| | | | Par | Pat | Vit | average. | |
| K/Na | Optimum 1 – 4 | 230 | 6 | 1.44 | 1.35 | 1,.95 | 12.2 |
| K/Mg | Optimum 2 – 5 | 25.5 | 9.61 | 10.5 | 11.6 | 10.36 | 1.8 |
| Ca/Mg | Optimum 1 - 2. | 0.77 | 0.72 | 0.91 | 2.6 | 1.29 | 2.3 |
| Ca/P | Optimum 1 – 2 (Max 3) | 0.23 | 1.6 | 0.55 | 1.15 | 0.98 | 6.6 |
| Mg/ (Na+K+Ca+P) | 0.15 – 0.25 (min 0,10) | 0.033 | 0.08 | 0.049 | 0.04 | 0.054 | 0.21 |

We can conclude:

1. Fertilizing with silt or rock flour gives better balanced crops than fertilizing with salts and/or most animal dungs;
2. Fertilizing with guano dung, brine, seaweed and a better balanced animal dung (Table 5: animal dung in Normandy, (Marchand, 1881)) gives also better balanced crops;

So the challenge is to improve the quality of animal dung and plant residuals.

The instruments we have for better fertilizing practices taken together:

- Different types of rock flour;
- Vermicomposts;
- Complete seaminerals;
- Seaminerals without NaCl, or with a low amount of NaCl;
- Seaweeds. Seaweeds have very high ash contents, up to ten times more than many interior crops (calculated from the data of Wolff (1871);
- And high quality cow dung (Marchand, 1881);

And there are still many questions. For instance: what type of silt or rock flour gives the best results if we wish to rebalance our crops? Do we need a mixture of granitic and basaltic rock flours in order to get an optimal balance? And which seaweed is the best for a better balance of our crops?

## Centers of origin

Maybe the research of prof. Vavilov gives us an indication.

Who is prof. Vavilov? Before Stalin brought Lysenko in charge of the Genetics at the Academy of Sciences, Prof Vavilov did a lot of research regarding the genetic sources of our agricultural crops. He developed a theory about the genes centers – the centers of origin -of our important crops (Glazko, 2013, 2014).

From 1930 onwards Vavilov was head of the laboratory for genetics in Moscow. This institution later on merged into the Institute for genetics of the Russian Academy for sciences. Then in 1940 prof Vavilov was, like many other scientists which opposed the ideas of Lysenko about genetics, put in jail by Stalin. In 1943 he died from hunger in Saratov. After his rehabilitation by Khrushchev the Russian Academy of Sciences introduced In 1965 the Vavilov price.

Where did Vavilov find the areas where our crops come from?

This is an image of the centers of origin (Figure 1).

* For this animal dung: see table four and five: cow dung in Normandy (Marchand, 1881)

† Sources: (University of Regensburg, 2008, Hensel, 1894: 25).

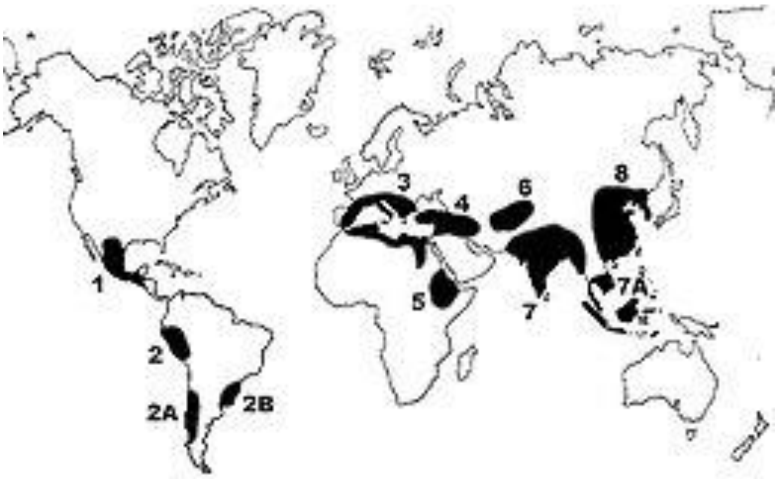


**Fig. 1.** Vavilov centers of origin: (1) Mexico-Guatemala, (2) Peru-Ecuador-Bolivia, (2A) Southern Chile, (2B) Paraguay-Southern Brazil, (3) Mediterranean, (4) Middle East, (5) Ethiopia, (6) Central Asia, (7) Indo-Burma, (7A) Siam-Malaya-Java, (8) China and Korea. (Center of origin, 2019)

1, 2, 3, 4, 5, 6 and 7* are all on fault Lines:

• in South America on the fault line of a continental plate and an Oceanic plate and in Asia and Europe on the fault Lines of different continental plates.

In South and Middle America we find the fault lines of the ocean plate – a.o. the Nazca plate – and the South American continental plate. This results in the Andean Mountains (Figure 2).

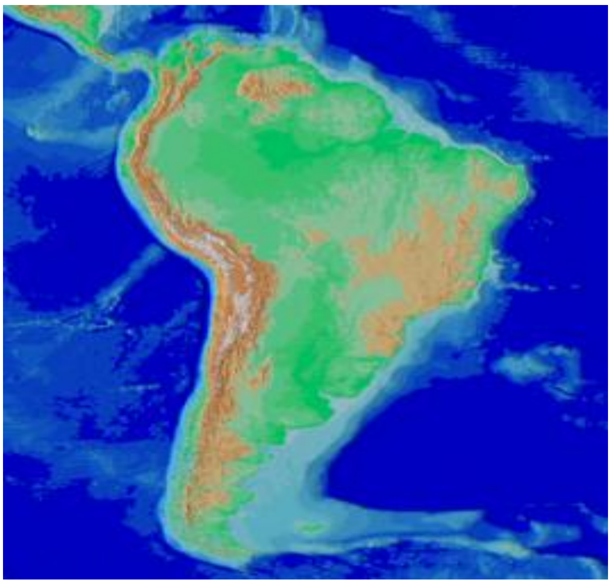

**Fig. 2.** Map of South America showing the Andes running along the entire western part roughly parallel to the Pacific coast of the continent (Andes, 2019)

In Eurasia we find the African plate, the Arab plate, the Indian plate and the Australian plate on one side, and the European-Asean plate on the other side. This gives the Alpine mountain range. This range goes from the Pyrenees in the West to the  Mountains in the Indonesian archipel in the East (Figure 3).

* Later on prof Vavilov found five more genes centers.

**Fig. 3.** The location of the alpine mountains on a map of Eurasia( Alpide belt, 2019)

• And we find also many flood basalts or traps (large igneous provinces) in these areas:

Within the area with nr 7 we find the Deccan plateau. Nr 8 is an area in southern China which was famous as the Chinese grain belt – Sechuan. Here the Emeishan trap is situated.

Partly these zones coincide with the socalled blue zones – zones where people live and dy in a healthy condition, and become old: parts of the mediterranean area (Sardinia); Uruguay; Ecuador; Ethiopia; the Karakoram (Hindukush); the fertile Crescent Moon (in the Middle East);

Many centers of origin coincide with areas where volcanoes from the earth mantle and the earth crust were and are situated, and at the socalled flood basalts: the highlands of Ethiopia (the Ethiopia-Yemen Continental Flood Basalts) ; the Deccan plateau in India; the Emeishan trap in the Sichuan province in Southern China; the countries between North and South America (the Caribbean large igneous province); Uruguay (Paraná and Etendeka traps);

Only in Indonesia and the Andes there is no flood basalt. But sometimes there are although basaltic volcanoes or layers. For instance, the active volcano at Bali – Mount Agoun – has the shape of a basaltic volcano* (Figure 4).

The slope is not a steep one but more slightly sloping. Earth crust volcanoes or stratovolcanoes are more steep. Basaltic volcanoes are more slightly sloping. And the black soil of the Agoun volcano looks like more basaltic than granitic. Like the black soil of the Deccan plateau.

* Officially this volcano is characterised as a stratovolcano, a steep granitic volcano [Electronic resource]. URL: https://www.theguardian.com/world/gallery/2017/dec/01/bali-volcano-mount-agung-in-pictures) (date of access 2019-12-22).

**Fig. 4.** A view of the Mount Agung volcano erupting in Karangasem, Bali, Indonesia, Monday, Nov. 27, 2017. (AP Photo/Firdia Lisnawati)

The type of volcanoes is an important distinction, because basaltic volcanoes are typically for the area where the first homo sapiens were found – in the south of Ethiopia:

"Omo-Kibish I (Omo I) from southern Ethiopia is the oldest anatomically modern Homo sapiens skeleton currently known (196 ± 5 ka)" (Hammond, Royer, Fleagle, 2017).

For the well functioning of our brains we need al lot of magnesium. So all crops from the magnesium rich centers of origin help us to get enough magnesium through our food. The teff from Ethiopia is an example of a grain with a good balance and high in magnesium. And the magnesium from teff is easily absorbed, because Teff is very low in phytic acid (which binds magnesium strongly) (Table 9).

**Table 9.** Elements and ratios in Teff (National Research Council, 1996: 222)

| Element | Amounts in Teff | Optimal ratios for human and animal food/day | Ratios | Ratios in teff |
|---|---|---|---|---|
| Ca | 159 | 1 – 4 | K/Na | 8.5 |
| Mg | 170 | 2 – 5 | K/Mg | 2.35 |
| P | 378 | 1 – 2 | Ca/Mg | 0.93 |
| K | 401 | 1 – 2 | Ca/P | 0.42 |
| Na | 47 | 0,15 – 0,25 Minimum 0,10 | Mg/ (Na+K+Ca+P) | 0.17 |

But once these crops grow in regions with less magnesium and/or wrong fertilizer practices they also get less magnesium. I think that many of our important agricultural crops are originating from magnesium rich areas. In the Netherlands wheat bread is the most important source of magnesium, but today the magnesium in wheat has gone down with almost 20 % (Guo et al., 2016).

Back to Vavilov: for the moment I presume that our centers of origin are located at soils which are faults and are mixtures of continental plates and basaltic volcanoes or floods. But that we have to check. The continental plates are rich in potassium and sodium containing feldspar and the basaltic volcanoes are rich in iron, magesium and trace elements. The Andes mountains have geologically spoken an in between position with the andesite minerals.

So what kind of lava rock meal we have to use?

As long as we are not sure about this question it is safer to use a mixture of basaltic lava and granitic rock flour.

Exceptions?

If the judgement regarding the place of the centers of origin at the faults is correct, we should also find these centers in the North West of the USA (Columbia river basalt group), in Canada (Chilcotin plateau basalts) and in Russia in the area of the Siberian trap. And there are more regions like these.

Amaranthus for instance is a crop which genes center is probably situated in South and Middle America or the North and South of the USA. But there is incertainty about its exact location of origin (Brenner et al., 2000: 229). Amaranthus grain is an excellent source of magnesium and has a good protein profile. Its Ca/P in the USA is too low. But there is a great spread in Ca/P values. Grain amaranthus AM MK (*Amaranthus cruentus)* from Africa has a much higher Ca/P (Kamga et al., 2013) than the grain amaranthus from the USA.

So far about the possible influences of the location of the centers of origin.

But what after growing a healthy crop?

A lot of elements and trace elements are lost by the way we mill our grains. The best is to use the whole grain kernel (as is the normal practice with teff), and not to remove the germs and bran. In the germs and bran are highly valuable components (see annex 3, Table 6 (wheat germ, and wheat bran)). And these we take off during milling and we give them to the pigs and chickens.

But if we want to use the whole grain kernel, then our milling facilities have to be more local in order to get the whole kernel flour to the bakeries as quick as possible, because the oil in the germs will otherwise make the bread rancid. Storing this flour for more than a few days is impossible.

Enough inspiration and questions for the next step: developing good fertilizing materials and practices.

## 3. Conclusion

Fertilizing with different materials (animal dung; artificial fertilizers, silt , seaweed, brine, guano dung, rock flours) influences the balance of the products grown on it. And it influences problably also the quality of the dung which is the result of the different feeds the aninals get from the differently fertilized fields. On the one side we see that fresh silt from the rivers is a complete fertilizer for some four to five years, with products which are better in balance with the exception of calcium and phosphor. On the other side the farmers from Normandy in the nineteenth century have shown that extra fertilizers like seaweed and brine also result in products with a better balance of its macro elements. Only calcium is still too low, and possibly the same for phosphor. In the modern crops (grains, potatoes, leafy crops) potassium is often too high (especially in potatoes and leafy crops), sodium is almost lacking completely. For magnesium the picture is not unambiguous. In most modern conventionally fertilized products magnesium is lower than in the products fertilized with silt, or seaweed plus brine and the better quality cow dung. But rye from the USA (2017) has a higher magnesium content than the rye from the UK (1945).

And we can't compare the abslute amounts of magnesium of crops grown on silt, on rock flour or in Normandy on dung plus seaweed and brine, with the other data, because the data from the silt, the rock flour and the Norman products concern the ash content, while the data from the other countries concern grams/kg dry weight. From more recent studies we know that the amount of magnesium in most crops has gone down substantially.

Most centers of origin where our crops come from, are situated on fault lines. Some of these fault lines are very rich in magnesium, because over there the earth mantle has come upwards in volcanic eruptions.

For finetuning we have to do trials with different kinds of silts, rock flours, seaweeds, vermicomposts and other.

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## Annex 1. Silt as fertilizer

**The Improvement of Land by Warping*, Chemically considered.** By Thornton J. Herapath.

"In many of the counties of England and Scotland, more particularly in those of Lincoln and York, there are certain districts, bordering upon the larger rivers and their tributaries, where the agriculturists are in the habit of manuring their land or of restoring its exhausted fertility by means of a peculiar mode of irrigation, which is there termed " warping." In order that this operation should be pursued with advantage, two points are necessary : namely, first, that the general level of the country through which the river flows, should be below that of high tide, and, second, that the water of the river should be of a very muddy character, as the main object of the farmer consists in producing an equal and uniform distribution of the alluvial matters, which are kept in suspension by the water, over the surface of the land.

For this purpose, the river-water, at low tide, is allowed to flood the land intended to be so warped by means of outlets in the banks of the river, and prepared channels and sluices, and it is then kept there until it has deposited the mud or silt with which it is charged. When this has taken place, the clear water is permitted to flow off by other channels and return to the river.

Fresh quantities of water are then again admitted at every succeeding tide, each of which produces a new superstratum of sedimentary matter, and this operation is repeated until the requisite thickness of warp has been obtained. The quantity of warp so deposited by each successive tide in many cases **exceeds one-tenth of an inch in thickness**; it varies, however, greatly at different periods of the year, according as there is much or little freshwater in the river

* To warp means "flooding the land".

and in the position of the land. By these means, then, there is created in the course of a few months a new soil of considerable depth, which consists, for the most part, of the various kinds of earth **and undecomposed vegetable and animal matters** which the waters of the river have collected and borne along in their course. Land so warped is said to possess a natural power of production of the most remarkable kind, **and a degree of fertility far exceeding that which is produced by any of the ordinary processes of cultivation**. In fact, vast tracts of perfectly sterile sandy and peaty soils in the neighbourhood of the rivers Humber, Trent, and Ouse are yearly converted into good arable land solely by the agency of this operation".

(..) By the above plan, however, it has been found possible to warp land in one year to the depth of **from 2 to 3 feet**, and this is generally considered to be quite deep enough and is permanent in its action).

(..)With regard to the qualities of warped land for the purposes of the agriculturist, it has been observed, that it is always best to allow land so treated to remain untouched for one

year, in order to afford time for the atmospheric air to act upon the alluvial matters and reduce them to a proper temper (if it may be so called) and state of dryness. It is then sown down with four bushels of oats per acre and a mixture of clover and grass seeds. The crops so produced are then depastured by sheep for two years in succession, when the soil is ploughed up and planted with wheat and oats. Beans and rape also thrive well upon this land ; the former have even been found to succeed as a first crop. Barley and turnips,

however, do not answer so well, on account of its slimy nature.

Warped land is grateful for manure, but does not require any until it has been cropped a few times, say for five or six years. **Guano** is then found to be one of the best that answers. Linseedcake and rich farm-yard manure also furnish very good results. Experience has proved, however, that the quality of the warp often makes considerable difference in this respect ; so much so, in fact, that one-half of a field has done better without additional manure than the other half has with" (Herapath, 1850).

## Annex 2. Minerals in seaweed

**Table 1.** Minerals in Brown seaweed (fucus) from Normandy

| Element | Fucus, g/ 165 g ashweight | Ratios | Fucus |
|---|---|---|---|
| K | 10.52 | K/Na | 0.45 |
| Na | 23.29 | K/Mg | 2.0 |
| Ca | 13.0 | Ca/Mg | 2.49 |
| Mg | 5.21 | Ca/P | 9.4 |
| Cl | 44.26 | Mg / (K+Na+Ca+P) | 0.11 |
| I | 3.36 | – | |
| Br | 1.05 | – | |
| P | 1.38 | – | |
| S | 9.08 | – | |

**Table 2.** The balance differs from Brown seaweed (Sargassum) in the Sabah's South China sea (Krishnaia, 2008):

| Element | Sargassum, mg/100 g DW | Ratios | Sargassum |
|---|---|---|---|
| K | 9700 | K/Na | 2.2 |
| Na | 4334 | K/Mg | 9.2 |
| Ca | 1130 | Ca/Mg | 1.07 |
| Mg | 1050 | Ca/P | – |
| Cl | Not measured | Mg / (K+Na+Ca+P) | – |
| P | Not measured | | |

**Table 3.** Wolff gives these data for seaweed collected in the harbor of Fécamp (Normandy, France) by Marchand (before 1865) Wolff (1871: 130):

| Element | Fucus siliquocus, (percentages) | Variety unknown (percentages) |
|---|---|---|
| K | 12.79 | 5.17 |
| Na | 11.46 | 15.14 |
| Ca | 7.18 | 10.35 |
| Mg | 4.53 | 3.97 |
| p | 1.11 | 0.95 |

**Table 4.** Ratios

| | Fucus siliquocus | Variety unknown |
|---|---|---|
| K/Na | 1.11 | 0.34 |
| K/Mg | 2.8 | 1.3 |
| Ca/Mg | 1.58 | 2.6 |
| Ca/P | 6.46 | 10.8 |
| Mg / (K+Na+Ca+P) | 0.14 | 0.125 |

So for agricultural purposes brown seaweed (low in potassium) and Fucus siliquocus (high for Mg / (K+Na+Ca+P)) seem favorable. And both have a relative high sodium level.

From chapter 8 about 'wild growing plants' in Wolff we can see that plants from the sea have in general very low amounts of phosphor. In fresh water the plants have some more phosphor. And most wild plants from the interior have much higher amounts of phosphor. But everywhere are some exceptions (Wolff, 1871: 130-145).

## Annex 3. Rye and wheat bread and flour in the Netherlands 2017

**Table 5.** Rye,The Netherlands 2017. Data from RIVM Nevo (RIVM Nevo, 2019)

| Food item | Sodium (mg) | Potassium (mg) | Calcium (mg) | Fosfor (mg) | Magnesium (mg) | Iron non haem (mg) | Cupper | Sele-nium (ug) | Zinc (mg) | Jodium (ug) |
|---|---|---|---|---|---|---|---|---|---|---|
| Flour rye 60 % extraction | 10 | 200 | 30 | 150 | 51 | 1.5 | 0.15 | 1 | 1.3 | 4.6 |
| Flour rye | 5 | 500 | 45 | 350 | 92 | 4 | 0.42 | 0 | 3 | 4.6 |
| Bread rye dark | 447 | 261 | 33 | 174 | 57 | 2.7 | 0.18 | 1 | 1.5 | 64.2 |
| Bread rye light | 407 | 256 | 34 | 178 | 55 | 2 | 0.2 | 3 | 1.43 | 77.1 |
| Bread rye dark low sodium | 30 | 261 | 33 | 174 | 57 | 2.7 | 0.18 | 1 | 1.5 | -- |
| Bread wheatrye wholemeal | 417 | 252 | 34 | 189 | 61 | 2 | 0.21 | 4 | 1.42 | 72.3 |
| Rye flakes rolled | 40 | 530 | 64 | 373 | 110 | 3.7 | 0.44 | 2 | 2.6 | 4.6 |
| Bread rye average | 443 | 260 | 33 | 174 | 57 | 2.6 | 0.19 | 1 | 1.49 | 65.6 |

**Table 6.** Wheat, The Netherlands. Data from RIVM Nevo (RIVM Nevo, 2019)

| Food item | Sodium (mg) | Potas-sium mg) | Cal-cium (mg) | Fosfor (mg) | Magne-sium (mg) | Iron non haem (mg) | Cup-per | Sele-nium (ug) | Zinc (mg) | Jodium (ug) |
|---|---|---|---|---|---|---|---|---|---|---|
| Flour wheat white 75 % extraction | 2 | 156 | 23 | 103 | 20 | 0.8 | 0.14 | 5 | 0.64 | 1.9 |
| Flour wheat wholemeal | 5 | 250 | 30 | 370 | 124 | 4 | 0.45 | 4 | 2.9 | 1.9 |
| Wheat germ | 3 | 900 | 62 | 1250 | 280 | 5.3 | 0.9 | 3 | 16.87 | 1.9 |
| Bread brown wheat | 439 | 166 | 29 | 142 | 43 | 1.4 | 0.16 | 4 | 1 | 69.3 |
| Wheat bran | 4 | 1160 | 110 | 1200 | 466 | 11.5 | 1.34 | 2 | 7.67 | 2.4 |
| Roll brown soft | 396 | 207 | 39 | 161 | 45 | 1.4 | 0.16 | 5 | 1.11 | 60.7 |
| Bread brown/whole meal average | 433 | 207 | 32 | 171 | 55 | 1.7 | 0.19 | 4 | 1.2 | 68.4 |

**Table 7.** Wheat and rye

| Element | Optimal ratios for human and animal food/day | Rye flour | Wolff 1871 Rye | Wheat flour (wholemeal) | Wheat germ | Wheat bran | Marchand 1869 Wheat |
|---|---|---|---|---|---|---|---|
| K/Na | 1–4 | 100 | 20.2 | 50.0 | 300.0 | 290.0 | 1.6 |
| K/Mg | 2–5 | 5.43 | 3.79 | 2.0 | 3.2 | 2.48 | 1.66 |
| Ca/Mg | 1–2 | 0.49 | 0.27 | 0.24 | 0.22 | 0.24 | 0.52 |
| Ca/P | 1–2 | 0.13 | 0.09 | 0.08 | 0.049 | 0.09 | 0.32 |
| Mg/(K+Na+Ca+P) | 0.15–0.25 Minimum 0.10 | 0.10 | 0.14 | 0.19 | 0.13 | 0.19 | 0.21 |