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II Potato – the hidden treasure

A. Krauss[(1)]

"*Potato – the hidden treasure*" is the motto of the International Year of the Potato, as declared by the UN for 2008. The Swiss Post Office even issued a special stamp for the occasion (www.post.ch, 2008).

Good reasons to celebrate this crop

It is number four in the global diet after rice, wheat and maize as a major staple crop

Indigenous to the Peruvian Andes and cultivated there for thousands of years, the potato plant was unknown to the rest of the world until the 16th century. It was first encountered by the Spanish conquistadors in their search for gold in Peru and it was they who returned home with it to Spain. First evidence of potato growing in Europe dates from 1565, in the Canary Islands. In the beginning, potato was considered as an exotic curiosity, but very soon it became an important staple food, particularly in Ireland. Since only a few varieties were initially introduced, however, genetic diversity was rather limited which left the crop very vulnerable to pests and diseases.

In the 17th century sailors took the tubers with them on their journeys and by this means the potato reached India, China and Japan. Irish immigrants imported the potato into North America in the early 1700s.

Dependence on this crop, especially by the poor, was the initial trigger for the Great Irish Famine of 1845 when late blight caused a disastrous crop failure which ultimately resulted in the deaths of about a million people.

Today, the global production is around 320 million mt, 40 per cent of which is

International Year of the Potato, Helvetia. A stamp issued by the Swiss Post Office. (http://www.swisspost.ch/en/print/pm-1-2008-jahr-der-kartoffel-085.jpg).

produced in Asia, almost the same (38%) in Europe, 12 per cent in North and South America and some four per cent in both Africa and Oceania (FAO, 2008a). This represents a substantial shift over the past 30-40 years in favour of Asia; in 1970 Asia produced only around 35 million mt or less than 12 per cent of the global 298 million mt, but Europe produced some 232 million mt or 78 per cent of total (Fig. 1). Currently, China is the largest single producer (73 million mt in 2005), followed by the Russian Federation (36 million mt), India (25 million mt) Ukraine and the USA (19 million mt each).

In Asia, potatoes have gained the status of a highly prized cash crop.

Compared to other major root crops potatoes represent about 43 per cent of the global output of root- and tuber-crops, followed by cassava with 30 per cent, and sweet potato with 17 per cent.

It is a very versatile crop suitable for both direct consumption and as an industrial crop

First of all, potato tubers are "non-fattening" because 100 g boiled potato contains only 87 kcal of energy and hardly any fat. For human consumption the potato tubers are not eaten raw but cooked to break down the starch. Potatoes provide the basis of many common dishes in which they are prepared in different ways. Amongst others they are baked, steamed, cut, sliced, mashed, fried, or roasted. Freeze-dried potato flour is added to grain flour for bread baking. In other words, there is a wide range of recipes around the world reflecting the versatility of the potato tuber as a source of nutrition. The highest per capita potato consumption is seen in Europe (93 kg/capita/yr), followed by North America (48 kg) and Oceania (43 kg). Globally, the per capita

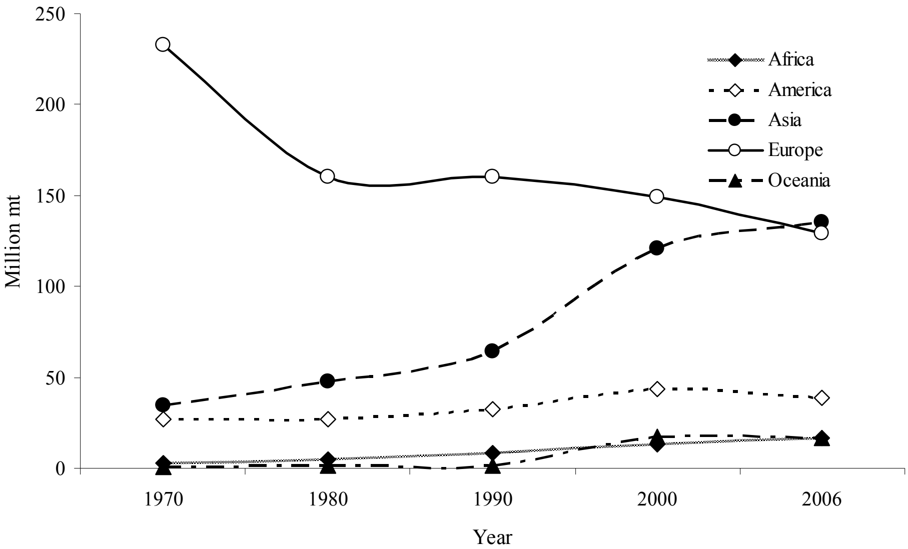

Fig. 1. Potato production by continent (source: FAOSTAT accessed 10-2008).

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consumption is 32 kg/yr (figures for 2003, FAO 2008a).

Starch from potato tubers is used in the pharmaceutical, textile, wood and paper industries, in the latter, for example as an adhesive. Since potato starch is 100 per cent biodegradable it is of value as a substitute for polystyrene and other plastics in disposable plates, dishes etc. Some potato is processed into fuel-grade ethanol. In Germany, for example, about 60 per cent of total potato production is used for food, 30 per cent for starch production and about two per cent for ethanol production (figures for 2005/06; Statistical Yearbook 2007).

Its tubers represent a very high nutritive value

FAO (2008b) shows the following nutrient content of potato tubers (per 100 g, after boiling and peeling):

Carbohydrate	20.13 g
Fiber	1.8 g
Fat	0.1 g
Protein	1.87 g
Water	77 g
Potassium	379 mg
Phosphorus	44 mg
Calcium	5 mg
Iron	0.31 mg
Vitamin C	13.0 mg
Niacin	1.44 mg
Thiamin	0.106 mg
Riboflavin	0.02 mg

The carbohydrates provide energy, fiber stimulates intestinal peristalsis, and the quality of tuber protein has the highest biological rating amongst plant products, comparable to that of egg. Of importance are the high contents of potassium and vitamin C, the presence of the latter the reason for potato often being called the "lemon of the North". The high K content is indicative of a particularly high K fertilization requirement; based on the above figure a moderate yield of 30 mt/ha would remove from the field some 110 kg K or the equivalent of 230 kg potash fertilizer i.e. K contained in almost five bags of muriate of potash (MOP).

It can be cultivated in a wide range of climatic and soil conditions

Potatoes are cultivated throughout the world except in the hot tropics and under cold arctic conditions. Under arid conditions drip irrigation is fairly common. Numerous cultivars, differing in tuber color, shape, size, starch content and maturity period provide a wide choice to accommodate the requirements of local soil and climate conditions, market and consumer expectations.

However, potatoes are very sensitive plants, especially with regard to tuber initiation and tuber growth. For instance, long daylight (18 h) or high temperature (30°C) prevents tuber formation. The control mechanism behind this relates to phytohormone activity, in particular in the ratio of the inducing phytohormone abscisic acid to the inhibiting hormone gibberellic acid; this ratio is rather low under non-inducing conditions but high under inducing conditions e.g. short day and/ or moderate temperature (Krauss & Marschner, 1982). It was also observed, that under constant high temperatures that root growth was strongly depressed which might be one of the reasons for disturbed phytohormone production and thus failure to induce tubers.

Another interesting aspect is the fact that tubers subjected to high temperature (30°C) ceased growth and, as important, both the incorporation of ^{14}C-labelled assimilates into starch, and the starch content were significantly reduced. Since the incorporation of ^{14}C-labelled assimilates into the sugar fraction was not affected by high temperature it can be assumed that under this adverse temperature regime the activities of some of the enzymes involved in starch metabolism were depressed (Krauss & Marschner, 1984).

Glassy-end tubers as often observed in hot dry summers are low in starch, which may relate to impaired starch formation. The treatment of growing tubers with gibberellic acid also changed the carbohydrate composition and enzyme activities towards a pattern which is characteristic of terminating the storage process (Mares *et al.*, 1981), similar to that observed at high tuber temperature.

And even small-scale farmers can achieve enough yields

Potato harvest can satisfy small-scale farmer's own food requirements and even contribute to income by selling excess potatoes at market. In Ireland in the 18th century, 0.6 ha of land used for potato cultivation was enough to supply a family of six for a whole year; to feed the same family on cereals would require four to six times more land (Ali 1999). Indeed, when the dry matter yield (assumed 20 per cent of fresh weight) of potato is compared with e.g. wheat it shows that for instance in India 3.28 mt/ha dry matter of potato (20% of 16.4 mt/ha) exceeds 2.6 mt/ha of wheat. Similarly, in the Netherlands, with the highest global potato yields of 44.7 mt/ ha, 8.94 mt/ha potato dry matter compares with 7.1 mt/ha wheat (figures for 2007; FAO 2008a).

However, the question arises as to whether the production of potato is also economical, from the viewpoint of energy use. In this respect Pimentel & Pimentel (2007) have considered the ratio between energy input and output for a range of crops. For potato cultivation, the input/output ratio in industrialized countries is positive, 1.33:1 in the USA and 1.57:1 in the UK, indicating that despite energy-rich inputs such as fertilizers, fuel and transportation, the high yields produced 30-60 per cent more energy than used in production. In the Philippines, however, with relatively low potato yields, the input of energy and labour required is high when compared to yield; the ratio

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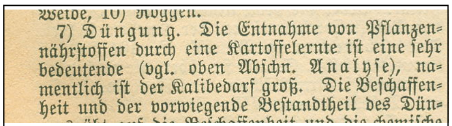
of kcal input/output is 1:0.42. In contrast, production of cassava in some developing countries (Thailand, Colombia, Vietnam and Nigeria) gained almost four times more energy than used in its production.

FAO (2008b) sees a particular function of women in potato production in developing countries. Rural women provide most of the labour – from conservation and seed selection to planting, harvesting, storing and marketing. In Peru for instance, the migration of men into urban centers in search of income has left women farmers responsible for almost 70 per cent of family farm work. From this type of evidence FAO concludes that women in developing countries play a central role in family food security.

A crop with a high yielding potential like the potato needs adequate supply of plant nutrients

In the IPI Bulletin No. 8 on potatoes, Perrenoud (1993) evaluating different sources showed that a good potato crop may remove at harvest around 100 kg/ha N, 50 kg/ha P_2O_5, 200 kg/ha K_2O, and about 10 kg/ha of both CaO and MgO. Total uptake (tubers and haulm) amounts to about 200 kg/ha N and 300 kg/ha K_2O, the maximum uptake being found to occur 95 to 120 days after planting with daily uptake rates of 2.5 kg N and 6.6 kg K/ha/day. Awareness of this high nutrient removal was already appreciated in the 19th century as published in "Thiel´s Agricultural Encyclopedia" (issued and edited around 1880 by Birnbaum & Werner), stating that "the removal of plant nutrients in harvested potatoes is very considerable, namely the demand for potassium is great".


Weide, 10) Roggen.
7) Düngung. Die Entnahme von Pflanzennährstoffen durch eine Kartoffelernte ist eine sehr bedeutende (vgl. oben Abschn. Analyse), namentlich ist der Kalibedarf groß. Die Beschaffenheit und der vorwiegende Bestandtheil des Dün-

An extract from Thiel's Agricultural Encyclopedia, 1880.

How does the potato plant respond to different nutrients? Let's have a look at more pronounced effects:

Nitrogen

Nitrogen (N) is a constituent of amino acids thereby playing numerous roles in growth and yield formation of plants. It is therefore not surprising that potato plants also respond well to N fertilization. However, as shown by Milford & Johnston (2007), it is essential to balance N supply with potassium (K) in particular (Fig. 2) because as reviewed by Pettigrew (2008), K is directly or indirectly involved in plant protein metabolism, beginning with the stimulation of NO_3 uptake and transport within the plant. Consequently, N fertilized together with adequate K results in better N recovery, in the given example, at the highest N rate from 35 per cent with NP to 54 per cent with the NPK treatment. This higher recovery also substantially reduces N loss to the environment. In this context it should be mentioned that potato plants have a rather flat root system. Therefore, high rates of N application at the beginning of vegetation present the risk of excessive N supply as a consequence of the high mobility of nitrate which allows it to be leached below the root zone with subsequent contamination of the groundwater. There is therefore a need to judiciously synchronize N supply with N demand of the crop. Perrenoud (1993) analyzed a range of fertilizer recommendations worldwide and concluded that a crop with less than 20 mt/ha yield is fertilized on average with 112 kg/ha N whereas at a yield above 25 mt/ha the crop receives 131 kg/ha N.

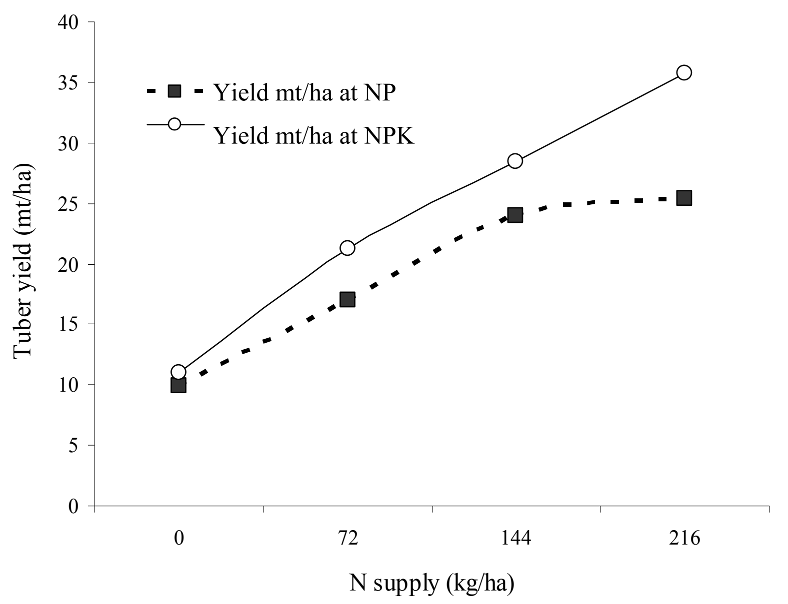


Fig. 2. NK interaction in potato (source: Milford & Johnston, 2007).

N deficiency is indicated by yellowish chlorotic leaves, starting in physiologically older parts of the plants. In contrast, plants supplied with excessive N show abundant shoot growth with dark green leaves.

Excessive N rates also affect the control mechanisms of tuber initiation and tuber growth. As shown by Krauss & Marschner (1982), continuous N supply resulted in prolonged stolon growth and prevented the formation of tubers because under these adverse conditions the activities of gibberellic acid (inhibitor) was relatively high compared to that of abscisic acid (promoter), i.e.

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continuous N initiated hormonal events similar to those under non-inducing long day conditions. Only after discontinuing the N supply for a few days did tuber initiation begin because of the shift favoring the activity of the promoting phytohormones. Resupplying N reversed the effect resulting in a cessation of tuber growth and the formation of new stolons at the apex of the tuber. By alternating supply and omission of N, tubers could be formed resembling a string of pearls (Plate 1).

Plate 1. *Resupply of nitrogen promotes formation of new stolons. Photo by A. Krauss.*

Phosphorus

As summarized by PPI-PPIC in Better Crops (1999), phosphorus (P) is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next.

As already mentioned, a moderate crop removes some 50 kg/ha P_2O_5 as harvested tubers. On average, potatoes are fertilized at lower yield level with 87 kg/ha and at higher level with 116 kg/ha P_2O_5. Sites with calcareous soils or acidic soils with high concentrations of free aluminum need special care because of P fixation in such soils.

Lack of supply in P is indicated by stunted growth with small, dark-green to purple discoloured leaves.

Potassium

As indicated, potassium (K) can be considered as a synergist in N metabolism. Quite apart from that, however, K is an important factor in many physiological processes such as osmoregulation, cell expansion, stomatal movement, and sugar metabolism. In this context, the proceedings of a recent conference on "Potassium and Magnesium, advances in research and application", should be mentioned. This was organized by IPI, IFS and the Sabanci University and held on 7 December 2007 in Cambridge, UK, and includes several papers reviewing the role of K (and Mg) on yield and quality formation in plants. The papers were later published at the Physiologia Plantarum, v. 133 (4). (see also at "New publications", page 19.)

Returning to the NK partnership, K uptake even exceeds the uptake of N. As mentioned by Perrenoud (1993), potatoes have a total uptake of around 300 kg/ha K_2O, of which 2/3^{rds} or 200 kg/ha are removed from the field with the harvested tubers. However, unlike N the K concentration in soil solution is rather small; movement of K towards the roots is mostly by diffusion - and not by mass flow as for nitrate - following a concentration gradient created by the removal of K from the soil solution adjacent to the root surface through uptake. As reviewed by Britto & Kronzucker (2008), K uptake by plant roots is an energy demanding active process requiring ATP.

In soils, K is compartmented in four distinct pools differing in availability to plants: (i) soil solution, (ii) exchangeable K, (iii) non-exchangeable K, and (iv) structural K (Krauss & Johnston, 2002; Rengel & Damon, 2008). There are reversible dynamic exchange processes between the pools. Potassium taken up from pool (i) is replenished by K from pool (ii) and – to a lesser extend – from pool (iii); after fertilization with potash, excessive K in soil solution, i.e. pool (i) is reabsorbed by the exchange sites of the clay minerals and organic substances. The bulk of K in plants derives from pool (i), the soil solution and thus from the easily available pool (ii), the exchangeable K. K from pool (iii), the non-exchangeable K is less available to plants albeit Trehan *et al.* 2005 (quoted by Rengel & Damon, 2008) identified several potato genotypes which could utilize K from the non-exchangeable pool. The genotypic difference in utilization of non-exchangeable K seems to be based on exudation of K-mobilizing compounds. Another interesting aspect in this context is the fact that potato grown in flowing nutrient solution culture required 9 times higher external K concentration than wheat or sugar beet to achieve 90 per cent of maximum yield (Trehan & Claassen, 1998).

Although K efficient potato genotypes may utilize non-exchangeable K and thus cope better under K deficient conditions, the replacement of K removed by the crop by adequate fertilization is indispensable for the benefit of the following crop. The high total K uptake within a short time span on one hand and the obvious need for relatively high K concentrations in soil solution on the other, are important indicators of the need to ensure adequate K supply, i.e. plenty of easily available K for potatoes.

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K deficiency is shown by necrotic leaf edges, starting on older leaves (Plate 2), often accompanied by early wilting. Excessive K supply on the other hand can adversely affect uptake of other cations, Mg in particular.

Another interesting aspect is the function of K in pest and disease resistance in plants. Nutrition of plants in general has a substantial impact on the predisposition of plants to be attacked or affected by pests and diseases. By its influence on growth pattern, anatomy and morphology and particularly chemical composition, the nutrition of plants may contribute either to increase or decrease resistance and/or tolerance to pests and diseases. As evident from the compilation of Perrenoud (1990) it has been found that K-deficient plants, especially in conjunction with high N rates contain relatively high concentrations of low molecular weight metabolites such as sugars and amino acids. The associated soft tissues (pale in colour) provide a good feeding ground for pathogens, as well as attracting aphids and allowing their easy access. Amtmann *et al.* (2008) develop further the relationship between K nutrition and disease resistance by looking into early defense signaling and the hormonal pathways in defense. Datnoff *et al.* (2007) show in their compilation that bacterial diseases of potatoes respond differently to K: incidence of potato scab (*Streptomcyes scabies*) is increased but that of soft rot (*Erwinia carotovora*) decreased. Canker (*Rhizoctonia solani*) can be either increased or decreased. Potassium depresses the incidence of late blight (*Phytophthora infestans*) as evident for example from the IPI-PRII-CPRI experiment in Jalandhar, Punjab (1997). Plots with no K added (-K) suffered severely from *Phytophtora infestans* (Plate 3).

Plate 2. *Typical symptoms of K deficiency in potato leaves. Courtesy of K+S KALI.*

Appearance of mosaic virus is lowered by K, whilst the incidence of leaf roll virus can be both increased and decreased. In other words, there is still space left for further research into the relationship between nutrition in general and K in particular and the incidences of pests and diseases in potatoes and other crops. The economic damage that pests and diseases can bring about should not be underestimated: Oerke *et al.* (1995) report that, during 1988-1990, of the total attainable production of 8 major crops (wheat, corn, rice, barley, soybean, cotton, potato and coffee), worth US$580 billion, about 42 per cent or US$240 billion are lost due to insects (15%), followed by pathogens (13%) and weeds (13%).

Plate 3. *Late blight (Phytophthora infestans) did not affect the plots with K, but devastated the crop without K treatment. Photo by P. Imas.*

K nutrition and potato quality is another aspect of economic relevance. In an overview on the K effect on yield quality, Krauss (2005) concluded "…crop quality is not a singular item that can easily be measured, it is rather complex and refers to subjective and objective parameters such as nutritive value, processing properties, taste and appearance. Although components of crop quality are genetically controlled, the nutrition of plants can alter the expression to a substantial extent. Through its versatile function in plants, K in the concept of balanced fertilization plays a particular role in quality formation as shown in numerous experiments and field trials around the world. Complying with the quality standards set by consumers and environmentalists warrants farmers who apply balanced fertilization to remain competitive in the market because of an ecologically sound and economically viable production method…". As far as potatoes are concerned, Haeder (1975) showed, for instance, that in potato plants receiving adequate amounts of K, 80 per cent of foliar applied ^{14}C was translocated within 2 h into the tubers, whereas K deficient plants retained more than 50 per cent of the absorbed ^{14}C in the shoot. A higher assimilate storage adds to nutritive value and quality. Potato trials in Bulgaria revealed that the content of reducing sugar dropped from 0.56 per cent with NP to 0.04 per cent

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with balanced fertilization with K and Mg together with NP (Nikolova, 1999). A low concentration of reducing sugar in potato tubers is mandatory for tasty and bright coloured potato chips and crisps. Gerendás *et al.* (2007) showed that increasing K always raised the citrate contents, but lessened the contents of reducing sugars, which serve as a precursor for acrylamide formation. Highest acrylamide contents (considered "likely carcinogenic for humans") were observed in tubers grown with high N and inadequate K supply. These results demonstrate that nutrient supply has a significant impact on the contents of acrylamide precursors and thus for acrylamide formation during frying.

Field trials with potatoes in Germany showed that the incidence of black spot decreased with increasing K content of tubers. Improving the K supply also led to increased starch content of potato tubers, the beneficial effect being more pronounced with sulfate of potash than with potassium chloride. The higher starch content returned a higher sales price with a quality bonus (Orlovius, 1996). Bansal & S. Umar (1998) reported from field trials in India that supplying potato with adequate potash increased tuber yield and dry matter content. At the same time, for potatoes grown for processing, chip color was improved and storage loss of fresh tubers was reduced. The latter is of particular economic importance because the market price of potatoes for instance in India increases considerably for some weeks after harvest. As an example, during the season 1997-1998, the price increased from Rs./kg 4.5 at harvest to Rs./kg 6 two weeks later and Rs./kg 8 four weeks later. This increased the value-cost-ratio (VCR) of potash from 16.6 at harvest to 21.4 and 28.5 two and four weeks later, respectively.

Potassium plays a particular role under saline conditions. As summarized by Shabala & Cuin (2008), salinity affects plant growth by imposing ionic and osmotic stresses because high Na levels in soil solution drives water out of cells. Secondly, there can be a specific Na toxicity, and third, salinity-induced nutritional disorders can occur in particular, induced K deficiency as a consequence of leakage of K from the root cells. In relation to the latter, high Na concentration in soil solution also reduces the activity of other essential nutrients, including K, and in addition, Na competes with K for uptake sites. On the other hand, salt-tolerance, as discussed by Shabala & Cuin (2008) "… is a complex multigenic trait …and is also multifaceted physiologically, with numerous tissue- and age-specific components involved…". Interestingly in this context, as shown by Krauss (unpublished results), ^{22}Na applied to leaflets of rooted potato sprouts is immediately translocated to the roots and excreted into the nutrient solution. This observation is in accord with other reports that potato is relatively sensitive to salinity and that K cannot to any great extent be substituted by Na (Marschner, 1995). The high K demand of the crop thus calls for particular care under saline conditions (amelioration, adequate K supply).

Magnesium

Magnesium (Mg) is often called *the forgotten nutrient*. Uptake and removal of Mg from the soil by potatoes is rather low (10 kg/ha MgO) as compared to K (up to 200 kg/ha K_2O). In the past this relatively low demand has not placed any major constraint on yield formation. However, continuously increasing Mg removal by higher yielding varieties and the tendency to focus on highly concentrated straight fertilizers will sooner or later give rise to the need for Mg fertilization on light soils. Calcareous soils, acidic soils with high concentrations of free Al as well as high rates of application of K and/or NH_4 fertilizers on Mg poor soils, especially sandy soils, all respond to Mg fertilization because of competition in Mg uptake. No doubt, Mg is one of the indispensable plant nutrients. As summarized by Cakmak & Kirkby (2008), Mg exerts a major influence on the partitioning of dry matter and carbohydrates between shoot and roots. Accumulation of carbohydrates in leaves is typical of Mg deficiency because Mg plays a fundamental role in phloem loading of sucrose. With impairment of phloem transport from the leaves it can be imagined that with Mg deficiency in potato not only root growth but also tuber growth suffers. Mg deficiency becomes very visible by developing chlorosis and necrosis on the leaves, especially when plants are exposed to high light intensity (Plate 4). The reason for this effect of Mg deficiency is the generation of highly reactive and detrimental O_2 species due to an over-reduction in photosynthetic e-transport (Cakmak & Kirkby, 2008). These authors plea for a high Mg nutritional status of plants, especially in regions with high light intensity. Foliar sprays

Plate 4. *Mg deficiency in potato leaves. Courtesy of K+S KALI.*

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with Epsom salt can quickly overcome inhibited assimilate transport and the appearance of photo-oxidative damage.

Calcium

Calcium (Ca) uptake and removal by potato crops is in the same order of magnitude as Mg, namely around 10 kg/ ha CaO. Apart from the need of Ca for ameliorating saline or acidic soils and thus improving the availability of essential nutrients such as K or Mg, Ca plays a particular role in development of stolons and tubers. Stolons are subsoil growing shoots. The developing tuber induces a high phloem influx but Ca is known to be rather phloem immobile so that there is hardly any Ca translocation from the shoot into the growing stolons or tubers (Krauss & Marschner, 1973). On the other hand, the stolons and developing tubers have the ability to absorb Ca directly from soil solution to meet their demand (Krauss & Marschner, 1975). Due to the relative immobility within the plant, Ca deficiency symptoms start at the growing point in plants. Die back of the apical buds is typical of Ca deficiency because Ca is an integral part of cell walls.

Sulfur

In the past there was no need for fertilization with sulfur (S) in industrialized countries because of the input of atmospheric S to the soil. In the seventies this amounted to up to 100 kg S/ha supplying enough to meet crop demand. However, a number of factors have contributed to reducing indirect S supply to crops. These include rigorous emission control of industry and traffic, the predominant use of highly concentrated mineral fertilizers. Additionally crop demand for S has risen as a consequence of increasing yields. The risk of S deficiency has thus become greater as the result of a lower S input but higher S export by crops. As reported by Schnug (2004), application of up to 50 kg/ha S in Poland to potatoes not only increased yield but substantially reduced the infestation of potato plants with canker (*Rhizoctonia solani*) and potato scab (*Streptomyces scabies*). The fungicidal effect of S relates to the synthesis of S containing metabolites such as phytoalexins, glutathione, glucosinolates and/or the liberation of gaseous H_2S (Bloem *et al.*, 2007). This “sulfur-induced-resistance (SIR)” has the advantage that according to Schnug (2004), the pathogens are unable to develop any resistance to sulfur.

Sulfur deficiency can easily be confused with N deficiency, namely small yellowish pale plants. Apart from leaf analysis, distance from industry, fertilizer practice and soil type may all provide evidence as to whether the plants are suffering from a lack of N or S. Additionally S deficiency always occurs first in the younger leaves whereas N deficiency appears in the older leaves.

A source of dispute is often the question whether potash to potatoes should be given as sulfate (SOP) or muriate (MOP). Pot experiments at the former K+S Büntehof Research Station in Hannover, Germany showed that potatoes fertilized with SOP were earlier in tuber initiation and growth than those fertilized with MOP. This difference in response could have some advantages in regions with multiple cropping when the time frame for potatoes is rather narrow. Also the processing quality (related to starch content) seems to respond better to SOP than to MOP.

Micro-nutrients

Dependent on soil conditions (pH value) there can be a particular requirement for fertilization with micro-nutrients, especially on calcareous soils. Sandy soils can also be poor in micro-nutrients. Foliar application is a common practice, either as chelates or in sulfatic form, sometimes added on application with a macro-nutrient like Mg in Epsom salt. Manganese and copper also exert fungicidal properties, incidences of potato scab obviously being more pronounced with Mn deficiency, and Mn- and/or Cu-containing fungicides are used to control late blight.

In Conclusion

The hidden treasure – the potato – is indeed a worthwhile crop for cultivation albeit the plant itself is sometimes very difficult to handle. The herbaceous habit of growth is inviting for many kinds of pathogens. The bulkiness of the crop places a greater demand on transport both at planting and harvesting as compared to cereals. Moreover the tubers, because of their high water content, require special care during storage. Nevertheless, the high nutritive value and versatility in use of the potato makes it an invaluable crop quite apart from the pleasure of enjoyment of the delightful fragrance of a field of potatoes in blossom.

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