Significance of potash fertilization with respect to the threatening climate change

J. Loch and I. Vágó
University of Debrecen, Faculty of Agriculture
loch@agr.unideb.hu

One far disputed question is whether nowadays a climate change takes place. Climatic change generally describes the change of the climate on earth during a longer period and thus also natural processes are contained. Often the global warming taking place in our lifetimes is also called climate change.

Under global warming, the observed gradual rise of the average temperature of the near earth atmosphere during the past decades is meant [1]. The term refers to changes of the climate caused especially by humans (antropogene changes). The causes are mainly burning of fossil fuels and the resulting emissions of carbon dioxide (CO2) as well as the release of further greenhouse gases.

As a consequence of the global warming, the frequency and intensity of weather extremes are increasing. The fluctuations are significant and they can lead to deviations in the global and regional climates. For preventing the negative effects, the processes are being studied world-wide.

Under patronage of the Ministry for Environment and the Hungarian Academy of Sciences, a project was created for the support of the climatic policy in Hungary in 2003 with the following objectives:

- Analysis of the changes and their effects on economy and society
- Preparation of the necessary measures for preventing, reducing the negative effects
- Legal regulation of the national strategy

The project was closed at the end of 2006, legal regulation is prepared based on partial studies [2], [3].

The trend analysis of the weather data confirmed the rising tendency of the temperature levels, a reduction in the amount of precipitation as well as an increasingly frequent occurrence of weather extremities. The variability of the measured values is increasing.[4]

The clearest changes in Hungary, lying in the Carpathian basin, can be observed in the temperature levels. The trend of the national average values follows that of the global warming, 0.7 ºC on average, as compared to the average values of many years. There are differences between the average values of the seasons: in the summer the warming is somewhat larger (about 1 ºC), in the autumn it is somewhat lower (0.4-0.5 ºC). The warming accelerated in the last 30 years.

The annual precipitation sums show a reducing tendency in the XXth century, particularly in the spring. At the end of the century, the sums were 75% of the values measured at the beginning of the century. The precipitation sums exhibit smaller fluctuations in the summer. Presently, the higher damages caused by draught are due to the rising summer temperatures. The reducing tendency of the autumn and winter precipitation is smaller, about 14-15%, but still significant, since consequently less water is stored by the soil.

A further unwanted feature is the rising intensity of the precipitation since, on one hand, fewer waters seeps into the soil, on the other hand, the danger of flood and/or flooding increases.

Based on these facts, it can be forecasted with large probability that a gradual warming, reduction of the precipitation and a larger variability in the weather extremities are to be expected in Hungary in the long run, which require prevention in the economy and in society [3].

The chronological analyses of the temperature levels prove that apart from the long-term rising trend, significant fluctuations take place, the negative effects of which can be observed in the crop yields.

The trend of the precipitation sums is clearly reducing, amounting to 40 mm/100 years on average at regional level. In the regional distribution, differences exist, the reductions are the largest in the southern regions. In the summer months, an increase of the dry days can be observed, up to a maximum of 45 days.

The amount of precipitation and the soil characteristics determine the water supply degree of the plant stock together, the unfavorable soil characteristics increase the danger of draught during low water supply [5].

From the above remarks, it follows that the climatological conditions determining plant production in Hungary cannot remain unconsidered. The most important factor is water supply, in the amount of which the common effect of temperature and precipitation is recognizable.

In the trend of the reducing amounts of precipitation, the occurrence of the critical years with less than 500 mm precipitation became more frequent, particularly in the southern regions. The water requirement of winter wheat, corn and sunflower, due to evapotranspiration, is largest in those vegetation periods, which had the minimum supplying values in the last 40 years. The water requirement of sugar beet is highest in August due to the increasing evapotranspiration during the vegetation period and remains high up to harvest [6].

It is to be concluded from the above, that in crop production, water and energy need to be spared as well as soil-protecting, site-specific production procedures adapted to the growing site need to be applied. One of the most important elements of these procedures is nutrient supply, a balanced fertilization adapted to the requirements of the plant and the local conditions. [7].

Water management and yield formation of plants

In yield formation, inner genetic factors and exterior growth factors determined by the environment (soil and climate) play a crucial role. Individual factors can be influenced by agrotechnical measures such as fertilization, plant protection, irrigation etc., while other factors, e.g. the groundwater storing capacity can hardly be altered.

The heavily or not changeable factors limit the yielding capacity of the locations. Often the water supply plays the limiting role, the lack of soil moisture hinders the nutrient effect.

Water management of the plant is determined by water uptake and water release. If the water release exceeds the uptake, a deficiency develops in the water balance, this happens in the case of strong transpiration, limited availability of water in the soil, or restrained metabolism of the root.

During water stress, the plant releases the weakly bound water, the hydrostatic pressure in the cell falls, which hinders cell elongation and growth. The plants can resist water stress to a certain extent, this ability is very different among the different plant species [8].

The adaptation method is based mainly on osmoregulation, the plant enriches the osmotically highly-effective materials in the cell. Such substances include: sugars, amino acids, cations and anions like K, Cl -, NO3 -. The increase of the osmotic concentration and the parallel dropping of the water potential cause an increased water absorption and an increase of turgor [9].

A further adaptation happens with water stress due to the formation of abscisic acid, which leads to closing of the stomata [10]. As soon as the potassium supply falls below a certain threshold, the turgor of the closing cells drops, and it results in the closing of the stomata [11].

The water utilization of the plants is marked by the transpiration coefficient, which indicates the quantity of water (in litres) used for the production of 1 kg dry matter. The values are different among the different plant species, as well as among locations and climates. Under arid conditions, more water is used, while under humid conditions less water is used. The C_4 type millet and corn have the lowest coefficients (277, 349), grain and root crops have values of 400-600, while red clover, flax and alfalfa use 700-800 litres of water/kg dry matter. The indicated values are subject to considerable fluctuations, which are dependent upon the nutrition in addition to the factors mentioned above.

It has been stated that the more growth factors are at the optimum, the better the water utilization of the plant is [12]. This finding has already been proven experimentally by Mitscherlich et al. [13]. Among nutrients, potassium has an especially favorable influence on the water management of plants [14].

Significance of potassium fertilization

Potassium as a nutrient is involved in the metabolism of plants in numerous ways. Numerous enzyme reactions are known, which are specifically activated by K^+ ions. Potassium promotes the processes of synthesis, photosynthesis, protein -, carbohydrate and fat synthesis.

The colloid-chemical interaction of mono- and bivalent cations (K^+ and well and/or approx. and mg) regulates the permeability of plasma colloids. The cation saturation of the colloids determines the material and water uptake and release. Potassium favours the water uptake of plants via roots and lowers the water release via the stomata of leaves. Potassium increases the draught and cold resistance of plants, improves the stem firmness as well as the resistance of plants to fungal diseases.

The diverse effects of potassium justify the significance of potassium fertilization. High yields and good quality are attainable only by a balanced fertilization. Potassium fertilization has special significance under arid conditions such as increasing temperature and precipitation fluctuations. The promotion of water uptake and the inhibition of water release enable a certain adjustment to weather extremities.

It worth noting that plants take up several time higher amounts of nutrients in the intensive growth stage than at the beginning or end of the vegetation period. The nutrients must also be present during intensive growth in sufficient concentration in the soil solution. In grains, disturbances at 2-3-leaf stages decrease the number of the ear-basic stems, which in the last stage of earing affect negatively the thousand-grain mass [15]. Fruit, tomatoes, wine grapes, potatoes and carrots also require high amounts of potassium for forming reserve organs.

The favorable effect of the potassium presupposes a balanced fertilization with other nutrients.

Plant production and fertilization in Hungary

The ecological conditions of Hungary are favourable for agricultural production. Therefore, a program for increasing yields was developed after World War II. The program was based on the increase of nutrient supply in the form of mineral fertilizers, since due to the low number of livestock (0.4/ha LU) the amount of organic manure was not sufficient [16].

The applied amount of fertilizers increased between 1960 and 1970 from 30 kg/ha total amount of raw nutrients (Σ N P_2O_5 K_2O) to 270 kg/ha. Between 1975 and 1985, the nutrient application level of Western European countries was reached. According to calculations of Kádár [17], the nutrient balance in the middle of the seventies became balanced at national level. With the rising fertilizer applications, the degree of nutrient supply in soils improved greatly. The simultaneous introduction intensive wheat varieties and corn hybrids led to two- to threefold increases in **national** wheat and corn yields [18].

At the beginning of 1990s, after the collapse of large-scale co-operatives, a large decrease in nutrient applications, the application of not only mineral fertilizers, but also that of organic manure, due to halving of the number of livestock, decreased to the level of the 1960s. Again a negative nutrient balance developed.

As a consequence of the negative nutrient balance, a yield reduction of 2.0 t/ha and 1.0 t/ha at national level was observed in corn and wheat, respectively, in the period of 1991 - 95 . The relationship between the reduced yields and reduced fertilization is remarkable despite the large number of yield-determining factors. At the same time, the nutrient content of soils available to plants diminished considerably.

After reaching the lowest point in 1995, a gradual increase could be observed in fertilizer use (Table 1). It is pleasing that apart from the easily rising nitrogen applications, the formerly completely neglected phosphate and potassium applications were doubled between 1996 and 2003. Thus the nutrient supply of crops became more balanced.

The European Union guidelines, as well as the regulations of the Ministry of Agriculture and Rural Development for the implementation of good agricultural practice and for retaining the good environmental conditions in agriculture, gave a new upswing to both soil examination and fertilization consultation.

It must be stated that the average values of the fertilizer supply vary between large boundaries. According to a national survey, in 2002, mineral fertilizers were applied only on 48% of the agricultural effective area. Organic fertilization was performed only on 7% of the area. From this it can be concluded that only a small portion of cultures are fertilized properly, at the same time however, a very extensive management endangering soil fertility is still followed on a significant part of the total area.

Table 1 Nutrient supply and wheat and corn yields in Hungary (1996-2003)

	1996	1997	1998	1999	2000	2001	2002	2003
Applied amounts of fertilizers in field crop, fruit and vegetable production kg/ha								
NPK	56	57	65	69	74	82	91	88
N	42	41	49	52	54	57	63	58
P_2O_5	7	8	8	8	9	12	13	13
K_2O	7	8	8	9	11	13	15	17
Wheat yield kg/ha								
	3280	4210	4140	3590	3600	4310	3510	2640
Corn yield kg/ha								
	5610	6410	5950	6380	4150	6220	5050	3950

It can be seen from Table 1 that only corn yields increased as compared to previous years in the studied period, on the contrary, wheat yields further decreased. In the fluctuations of the yields, the effect of weather is recognizable. The opposite tendency of wheat and corn yields can be explained on the one hand with the fact that wheat and corn respond more sensitively to nutrient supply and weather conditions, respectively [19], on the other hand, corn is produced predominantly according to the regulations of production corporations (KITE, HAGE) and thus is sufficiently fertilized.

The exploitation of the ecological potentials, as well as the consequences of global warming require new considerations in crop production. As main goals, preservation of the soil fertility with minimum load of the soils, as well as a balanced fertilization adapted to crop requirements and local conditions are to be set.

Summary

Research work of the past years on climatic policy in Hungary lead to the conclusion that a gradual warming, reduction of the precipitation and a larger variability in the weather extremities are to be expected in Hungary in the long run, which require prevention in the economy and in society.

In crop production in Hungary, water supply plays the limiting role, the lack of soil moisture often hinders the nutrient effect. With strong transpiration and small water availability in the soil, a deficit in the water management of the plant develops and cell elongation and growth are hindered.

The adaptation of plants to water stress is based mainly on osmoregulation, the plant enriches the osmotically highly-effective materials in the cell. The increase of the osmotic concentration causes an increased water absorption, and a consequent increase in turgor. The formation of abscisic acid restrains water release by closing the stomata. As soon as the potassium supply falls below a certain threshold, a closing of the stomata follows.

It is well-known that the more growth factors are at the optimum, the better the water utilization of the plant is. Among nutrients, potassium has an especially favorable influence on the water management of plants.

High yields and good quality are attainable only by a balanced fertilization. Potassium fertilization has special significance under arid conditions such as increasing temperature and precipitation fluctuations. The promotion of water uptake and the inhibition of water release enable a certain adjustment to weather extremities.

The ecological conditions of Hungary are favourable for agricultural production. The rising level of fertilizer application and the introduction of the intensive varieties, led to the duplication of wheat and corn yields at a national level between 1960 and 1990, the nutrient content available to plants increased. The drastic decrease of fertilizer application at the beginning of the 1990's caused a gradual reduction of wheat yields until 2006. In the case of corn, a rising trend of yields is to be observed after a former reduction. The fluctuations of yields are due to the weather, which had a more pronounced impact in the case of corn.

After the minimum value reached in fertilizer application in 1995, a gradual rise is to be observed. Apart from easily rising nitrogen application, the formerly completely neglected phosphate and potassium applications were doubled between 1996 and 2003. Thus the nutrient supply of crops became more balanced.

The average values of the fertilizer applications vary between large boundaries at a national level. Only certain cultures are fertilized according to the crop requirements. On an important part of the total area, a very extensive management endangering soil fertility is still followed.

The exploitation of the ecological potentials, as well as the consequences of global warming require new considerations in crop production. As main goals, preservation of the soil fertility with minimum load of the soils, as well as a balanced fertilization adapted to crop requirements and local conditions are to be set.

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