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Effect of potassium on the metabolism of sugar beet plants infected with beet yellows virus

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Sugar beet foliage may turn yellow as a result of unfavourable soil conditiom or attack by various fungus diseases, but the most common and important, froof the commercial point of view, is the virus disease known as yellows. In case of infection of very young plants, a crop can lose about half of its potential yield ns sugar [7, 9, 10, 26, 28, 30].

Symptoms of virus infection and some disturbances in plant metabolism have been reported or described by several authors [3, 4, 8, 11, 16, 24, 27, 29, 30]. In view of their papers, it is known that yellows causes some disorders in carbohydrate and nitrogen metabolism, in assimilation of CO_2 and so on. On the other hand, much has been written about the essential role of potassium in healthy plants, in the above mentioned processes [2, 6, 12-15, 17-22,31, 32]. Thus, it was interesting to find out what effect on the growth and on changes in the metabolism of infected sugar beet will have the increasing doses of potassium, especially concerning changes which are responsible for reducing the final yield.

Therefore a study was made on the relation between infection with beet yellows virus and rate of growth, water balance, size of assimilating system and its efficiency, sugar production, rate of the uptake of potassium sodium, calcium and nitrogen by sugar beets grown at different potassium levels.

The plant material was grown in a greenhouse in sand cultures. Two groups of plants were studied in the experiments: a not infected one as a control, and one infected with beta virus 4. Plants were inoculated about 10 days after planting, each with 10 aphids (*Myzus persicae* Sulzer) previously fed for 24 hrs on the infected plant — *Tetragonia expansa*. All plants received the same stock nutrient solution. Only potassium was differentiated and its doses were: 250, 1,000, 2,000, and 3,000 mg of potassium oxide per pot.

According to the usual growth-analysis procedure [1, 5, 23-25], measurements of leaf area and dry weight were taken five times at 15 days sampling intervals, throughout the growth period; from these data the net assimilation rate was calculated.

RESULTS

Plants infected with beet yellows virus began to show visible symptoms about 3 weeks following inoculation. These symptoms were similar to the previously described ones i. e. leaves grew yellow with development. Generally, chlorosis started to develop from the tips of leaves downwards. At the third and subsequent samplings — 60, 75, and 90 days after planting, the old leaves of beets were severely yellowed.

It was particularly interesting that the intensity of symptoms depended on the level of potassium nutrition. Symptoms appeared slightly earlier (2-5 days) and were more severe in plants supplied with deficient doses of potassium. Similarly at the end of the vegetation weaker symptoms of virus infection were observed in plants grown on high doses of potassium (Fig. 1). A slower development of symptoms in plants at high-K level undoubtedly must be attributed to potassium, because other environmental conditions of the vegetation remained the same.

Fig. 1. Intensity of disease symptoms of sugar beet plants infected with sugar beet yellows virus in relation to potassium treatment (295 = 250 mg K_2O/pot, 309 = 2,000 mg K_2O/pot, 333 = 3,000 mg K_2O/pot).

Visual symptoms of virus infection were followed by some disorders in the host-plant metabolism. The virus infection was accompanied by an increase of transpiration rate (Table 1). Also a depression of transpiration productivity was a consequence of the infection. This implies that physiological efficiency is lower in infected sugar beets. High doses of potassium, at the water balance, resulted in limitation of the transpiration rate. The value of the coefficient of transpiration productivity was highest under conditions of highest potassium supply, especially at the end of vegetation.

One of remarkable changes in the composition of sugar beet leaves induced by yellows, was an increase in the content of reducing sugars (Fig. 2). At all samplings, the yield of these sugars in the leaves of healthy plants was lower than in

Table 1

Effect of potassium on productivity of transpiration of sugar beet plants infected with beet yellows virus (g dry m./1000 g H_2O)

K_2O treatment mg/pot		Duration of growth in days				
		1-30	30-45	4-60	60-75	75-90
Not infected plants	250	1.37	3.19	3.42	2.89	3.16
	1,000	1.64	3.33	3.74	3.18	3.45
	2,000	1.18	3.51	4.06	4.15	4.34
	3,000	1.18	3.33	4.32	4.35	4.25
Infected plants	250	1.08	2.90	3.13	3.08	2.68
	1,000	1.30	3.35	3.47	3.00	3.19
	2,000	1.06	3.75	3.63	3.46	3.87
	3,000	1.26	3.26	4.10	4.08	4.01

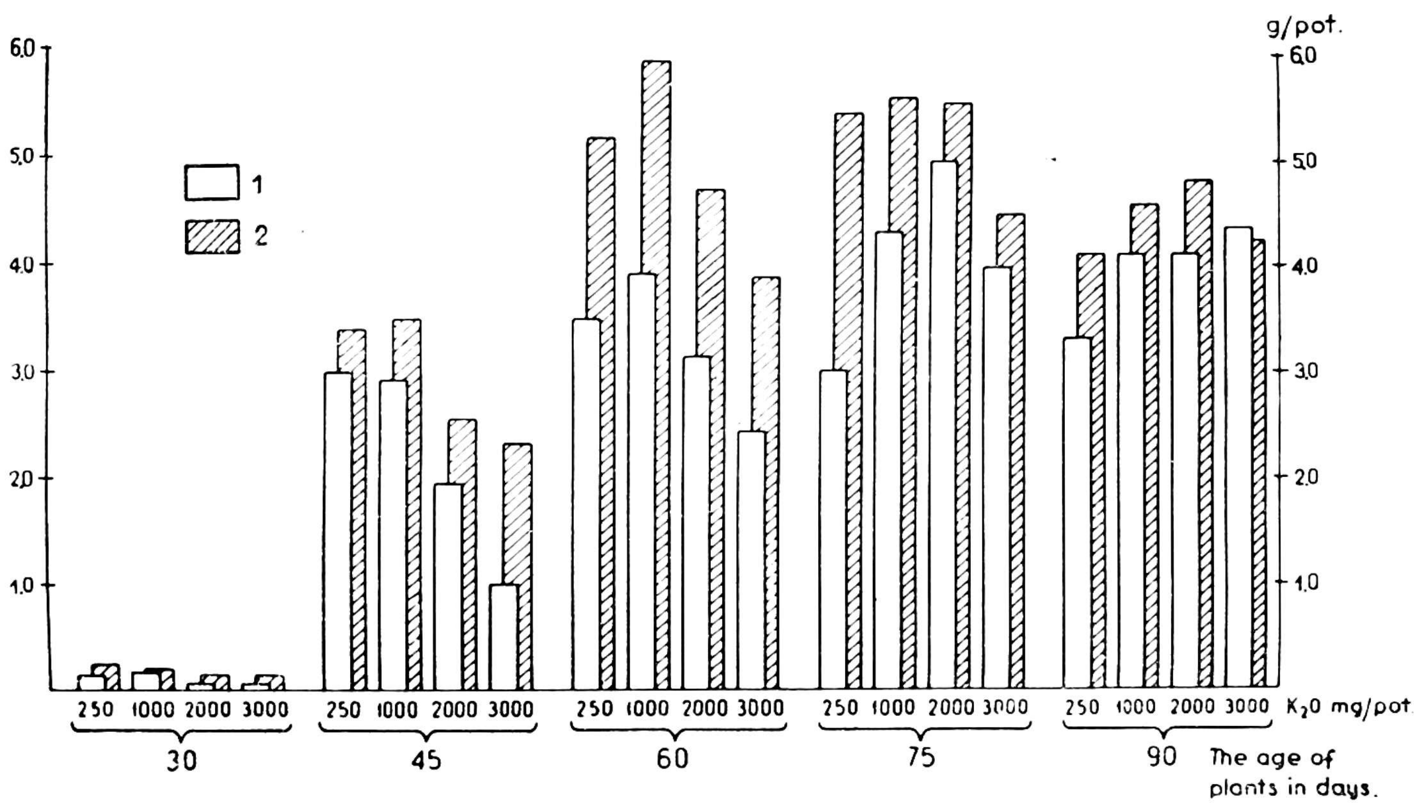

Fig. 2. Effect of potassium on the yield of reducing sugars in leaves of sugar beet plants infected with sugar beet yellows virus. *1* — non infected plants, *2* — infected plants.

the leaves of virus infected beets. Potassium counteracted this negative effect of infection.

A cardinal difference between the roots of healthy and infected plants was visible in the yield of sucrose (Fig. 3). The yield of sucrose of infected roots has been presented as a percentage of the yield of healthy roots. It should be mentioned, that the yield of sucrose of infected roots was decreased not only because of root weight reduction, but a reduction in the percentage of sucrose content was there as well. It can be seen, that potassium reduced the losses of sucrose yield per plant. Due to such an effect of potassium, the yield of sucrose of infected plants increased parallely to the level of potassium in the nutrient solution. Thus, differences between the total amount of sucrose in infected and healthy plants grown

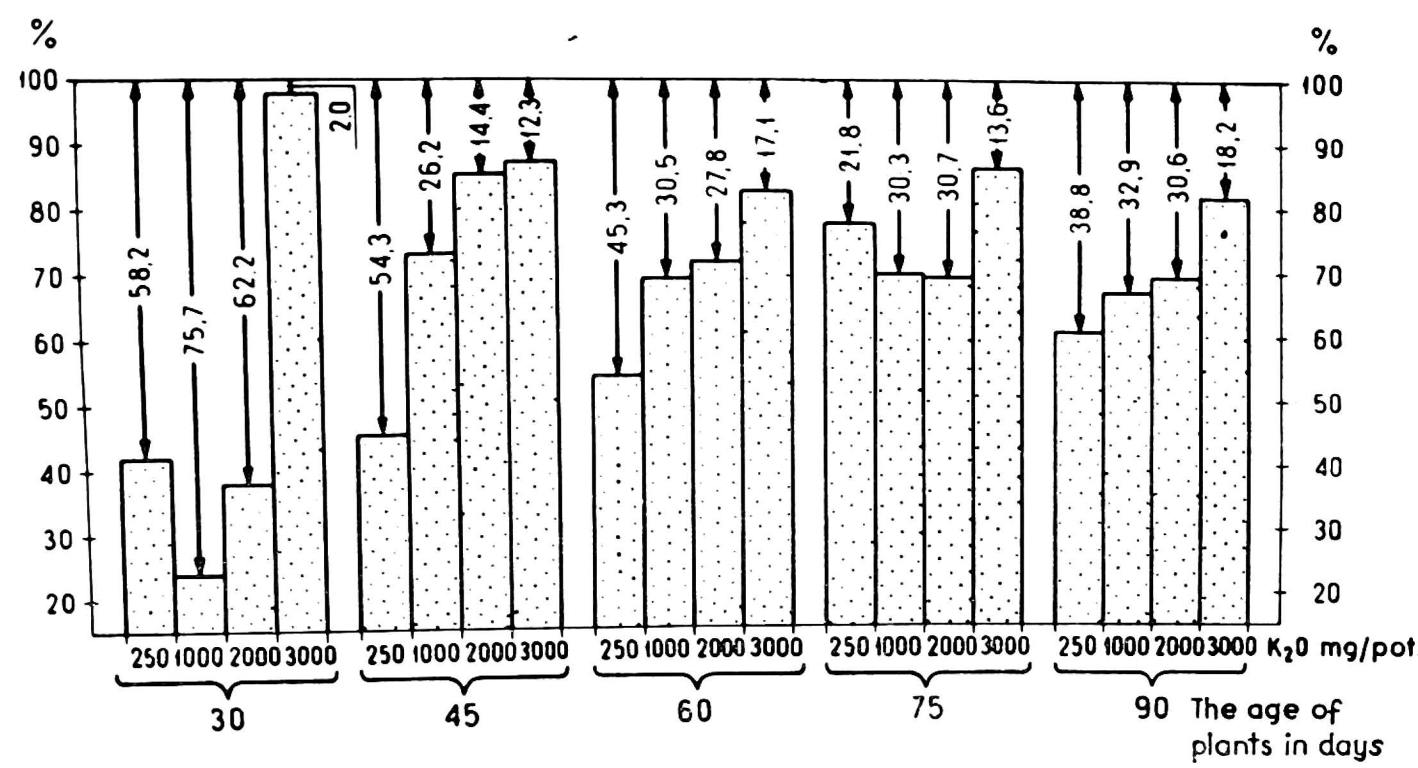

Fig. 3. The effect of potassium on the yield of sucrose in the roots of sugar plants infected with yellows virus (the yield of sucrose in the root of the not infected plant = 100%).

at optimal potassium levels were smallest. This relationship was observed during the whole period of vegetation, and it was also true for the percentage of sucrose content of roots.

The destructive effect of infection on the assimilation rate resulted from the diminution of both, the size of photosynthetic system and its efficiency. Yellows caused a reduction of the leaf area and net assimilation rate as a result of reduced productivity of the photosynthesis of leaves (Table 2). Potassium counteracted the

Table 2

Effect of potassium on net assimilation rate of sugar beet plants infected with beet yellows virus ($mg/dcm^2/day$)

K_2O treatment mg/pot		Duration of growth in days				
		1-30	30-45	45-60	60-75	75-90
Non infected plants	250	50.43	141.41	67.67	25.55	
	1,000	57.74	111.94	56.91	40.26	54.74
	2,000	41.19	137.55	68.92	61.53	54.60
	3,000	43.12	143.72	68.80	49.62	46.48
Infected plants	250	44.21	108.65	45.77	60.40	
	1,000	44.82	129.40	33.91	34.48	45.56
	2,000	35.10	151.58	39.88	58.11	49.13
	3,000	47.91	121.84	73.16	48.85	29.72

negative effect of infection. It caused an increase of assimilating leaf area. Moreover, leaves of beets grown under high-K supply conditions were physiologically younger in comparison with leaves of the remaining plants. It allowed them to maintain higher photosynthetic efficiency during a longer period of growth.

In this way, differences between healthy and inoculated plants in transpiration rate, sugar production, rate of dry weight accumulation, led to differences in the final yield of dry weight, especially of roots (Fig. 4). Beta virus 4 had no significant effect on the dry weight of leaves. Figure 4 indicates also the influence of potassium on the changes in dry weight losses of roots caused by infection. These losses are expressed as percentages of dry weight of healthy plants. The results indicate

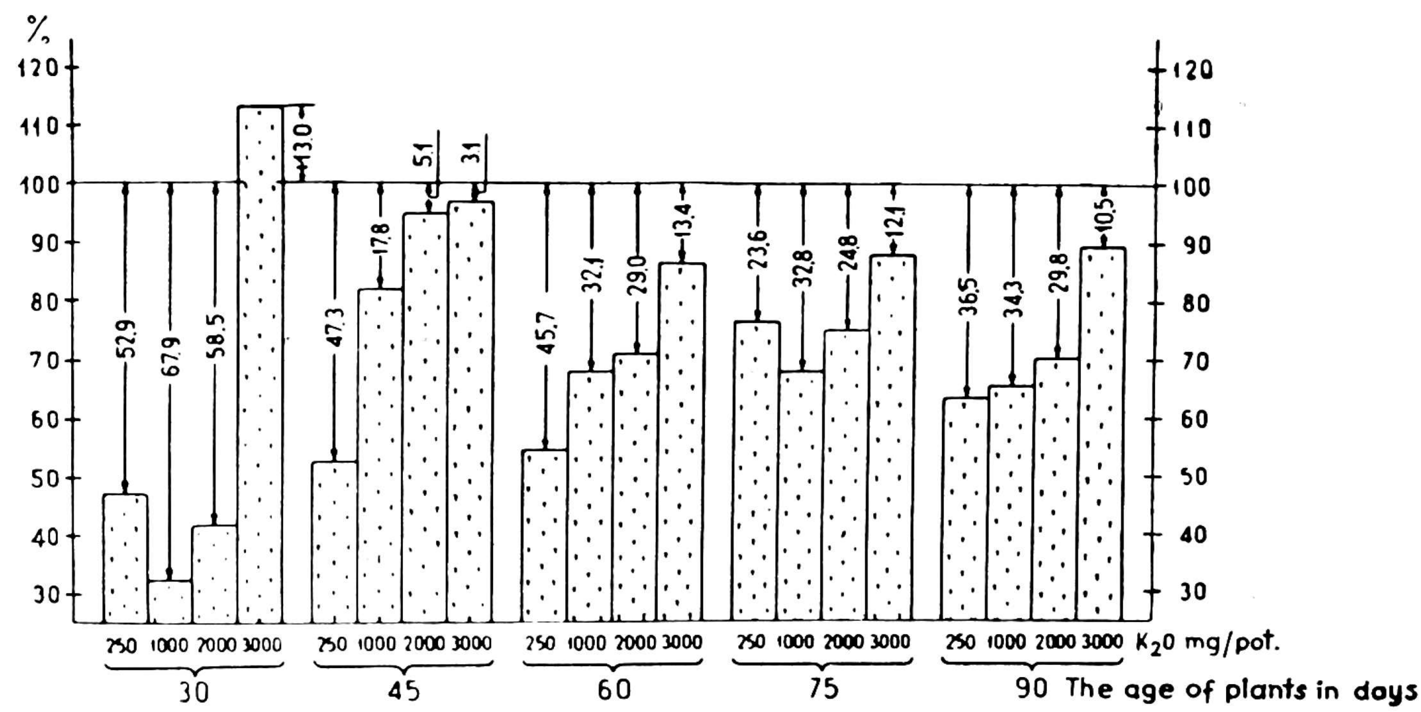

Fig. 4. Effect of potassium and infection on the dry weight yield of roots of sugar beet plants (yield of a root of a healthy plant = 100%).

that both, potassium and virus influenced the yield of dry weight of sugar beet roots. The relative importance of potassium and infection varied with the amount of the potassium fertilizer and the age of plants. A reduction of yield caused by infection in potassium-deficient plants (sugar beets receiving 250 and 1,000 mg K_2O) was greater than in comparable high-K plants. In other words high doses of potassium depressed the losses of dry weight, which arose as a result of the virus infection.

A chemical analysis of plant material shows that infection had no significant effect on the uptake of potassium, natrium and nitrogen, but it markedly depressed the absorption of calcium by plants (Table 3).

The presented results of pot experiments show that yellows caused serious changes in some living processes of sugar beets as a host plant. But the value of the loss of dry weight and sucrose yield of roots depends on potassium supply. The level of potassium which, to some extent, depressed the growth of healthy plants appeared as most efficient for infected beets. Thus it seems, that potassium requirement for infected sugar beets tends to be higher than for healthy ones.

Table 3

Amounts of calcium absorbed by sugar beet plants infected with beet yellows virus grown at different potassium supply (mg CaO/pot)

	K_2O treatments mg/pot	Age of plants in days									
		30		45		60		75		90	
		not infected	infected	not infected	infected	not infected	infected	not infected	infected	not infected	infected
Tops	250	135.65	106,64	560.49	468.29	926.55	756.14	946.96	921,39	1,063.48	908.62
	1,000	112.20	88.56	467.72	397.65	718.12	633.49	694.44	649.35	765.74	763.84
	2,000	57.56	46.72	318.80	276.63	469.04	349.93	647.28	532.43	721.14	655.87
	3,000	39.31	47 06	267.52	215.71	416.13	391.25	508.23	416.26	657.66	490.21
Roots	250	7.99	3.76	50.27	33.48	144.08	100.51	179.36	163.98	291.63	167.93
	1,000	7.16	2.50	40.28	33.08	143.08	112.43	214.49	138.14	312.93	221.69
	2,000	3.53	1.36	27.48	31.28	144.42	109.44	191.02	122.76	265.50	216.52
	3,000	2.76	2.89	21.01	20.36	115.80	96.45	126.65	92.83	191.64	205.10
Total (root + top)	250	143.64	110.40	610.76	501.77	1,070.63	856.65	1,126.32	1,085.37	1,355.11	1,076.55
	1,000	119.36	91.06	508.00	430.73	861.20	745.92	909.43	787.49	1,078.67	985.53
	2,000	61.09	48.09	346.28	307.91	613.46	459.37	838.30	655.19	986.64	872.39
	3,000	42.07	49.95	288.53	236.07	531.93	487.70	634.88	509.09	849.30	695.31