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SUMMARY

In a 60 years trial different potash fertilizers (KCl with 40 resp. 50 p. 100 K_2O, K_2SO_4 and kainite) were proved for yields and potassium uptake of different crops as well as for effects on K dynamics of a brown earth (pH 6.3) with 1.6 p. 100 total K.

Between the + K and — K plots, there was a difference of about 1 000 dt/ha in total dry matter production and of 2 500-3 000 kg K/ha in potassium uptake. The utilization rate of the different K-forms was 44-50 p. 100, the best results gave the highly concentrated chloride forms, the lowest kainite. The potassium content of the plants was increased significantly by potash fertilization (especially in vegetative organs).

The response of crops on K fertilization was the highest for potatoes (60-80 p. 100 increase) and the lowest for wheat and barley (10-14 p. 100 increase). The total annual K uptake of different crops ranged between 60 (barley) and 270 (sugar beets) kg K/ha.

The quality of crop products was improved in all cases. The pH of the soil did not change after 60 years K fertilization.

CAL- and DL-extracts differentiated fairly well between — K and + K plots; however even after this long fertilization period the CAL-resp. DL- level did not exceed 10 mg K_2O/100g soil nor expressed the high K removal of the soil K from the controls.

The total exchange capacity of the soil was decreased by long-term kainite application; the sodium sorption increased extremly in the whole profil by this way. The potassium sorption was nearly the same in the + K and — K plots; Ca and Mg were definetly higher in the controls.

In 1913 a potassium fertilizer trial was started on our experimental station at Weihenstephan (near Munich), which now belongs to the eldest trials of this kind in Germany. The experimental plan remained unchanged since that time and took the aim at the following question :

Effect of long-term potassium fertilization on yields, quality and potassium uptake of different crops as well as on potassium dynamics of a brown earth (Weihenstephan).

LOCATION

Climate

Weihenstephan lies 467 m on sea level at the edge of tertiary hill land. It exhibits 1 840 hours of sunshine yearly and an average air temperature of 7.7°C ; in July the temperature reaches about 17°C (fig. 1). The average sum of rainfall comes up to 800 mm/year with a steep peak in July.

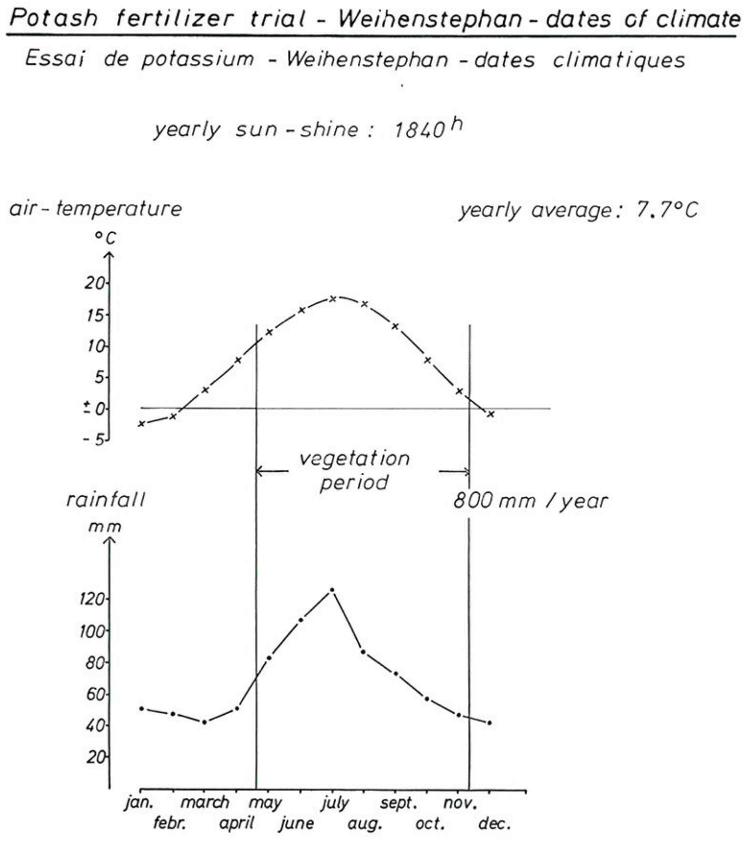


Fig. 1.

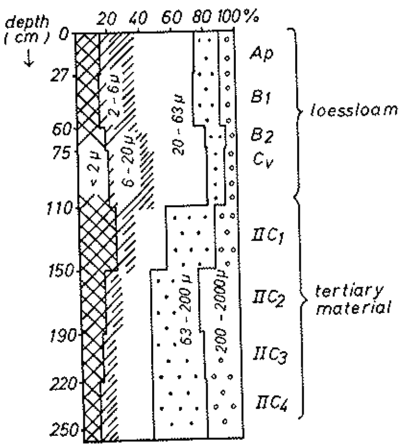
Soil

Physical data (fig. 2).

The soil may be classified as loess-loam above tertiary material (clayey sands to sands). The top soil consists of 20 p. 100 clay (< 2 μ), further 20 p. 100 correspond with fine silt (6-20 μ) ; about 30 p. 100 are particles between 20 and 63 μ diameter (coarse silt), the rest is fine respectively coarse sand. According to the distribution of the different particles in the top soil, this type

Physical data of the soil

Caractères physiques du sol



soil texture	porosity volume %	effect. field capacity mm
uL	42	32
sU	36	30
uL	34	14
uL	34	32
sL	36	52
sL	–	Σ 160
lS	–	
lS	–	

FIG. 2.

TABLE I

Chemical data of the soil

Caractères chimiques du sol

depth (cm)	pH (CaCl2)	C %	N %	total K	K2O CAL*)	total P	P2O5 CAL*)	P2O5 DL**)	Mg (CaCl2)	TEC°)	CEC°°)	Na	K	Ca	Mg	base sat. %
				mg / 100g soil						meq / 100g soil						
0–27	6.7	0.81	0.10	1.54	10	83.3	20	36	10	12.0	11.7	0.03	0.18	10.6	0.89	98
27–60	6.7	0.38	0.06	1.55	7	56.7	4	7	10	10.7	10.5	0.01	0.10	9.4	0.95	98
60–75	6.8	0.31	0.05	1.66	7	54.9	3	5	15	11.9	11.0	0.01	0.14	9.3	1.55	92
75–110	6.3	0.36	0.06	1.67	8	62.3	4	4	25	11.9	9.9	Sp	0.15	7.4	2.30	83
110–150	6.1	–	–	1.60	8	48.8	3	3	31	14.7	12.3	0.01	0.18	9.0	3.16	84
150–190	6.1	–	–	1.53	7	43.6	2	2	27	11.8	10.1	0.01	0.14	7.4	2.56	86
190–220	6.0	–	–	1.57	7	36.6	3	3	25	13.0	9.4	n.n.	0.12	6.9	2.36	72
220–250	6.1	–	–	1.61	7	39.7	3	3	25	11.4	9.4	0.02	0.12	6.9	2.39	82

°) TEC = total exchange capacity
°°) CEC = cation exchange capacity

*) CAL = calcium acetate lactate
**) DL = double lactate

of soil can be characterized as silty loam with a porosity volume of 42 p. 100 (in the upper horizon) respectively 35 p. 100 (in deeper zones) and an effective field capacity of 160 mm in the profil down to 150 cm depth (HARTGE, 1971).

Chemical data (table 1).

The pH-value ($CaCl_2$ extract) in the upper soil is about 6.7 ; the total-C content decreases from 0.81 p. 100 in the top soil to 0.36 p. 100 (between 75-110 cm depth).

The total potassium is roughly 1.5-1.7 p. 100 in the loess as well as in the tertiary material ; about 0.5 p. 100 from that is CAL-extractable (SCHÜLLER, 1969) with an evident increase in the top soil as a consequence of long term K fertilization. The total P content is moderate, in lower zones very poor ; the CAL-respectively DL-values are again highly improved by P fertilization. The $CaCl_2$ extractable magnesium is high and increases in deeper zones.

On total exchange capacity (TCE) Ca shares with about 90 p. 100 and Mg with about 7 p. 100. In lower zones the Ca-sorption decreases to approximately 70 p. 100 but Mg increases to about 20 p. 100. Compared with these the potassium ranges only between 1.5 p. 100 (top soil) and 1 p. 100 (in the tertiary material).

All the methods not especially quoted are from « *Handbuch d. Landw. Versuchs- u. Untersuchungsmethodik*, 1955 ».

Field trial

This long term experiment was layed out 1913 according to the following plan (table 2) and represents a comparison between different potash fertilizers on the base of an normal nitrogen and phosphorus fertilization. According to the percentage of secondary constituents, very different amounts of chloride, sulfate, magnesium and sodium have been applied since more than 60 years (table 3).

TABLE 2

Experiment plan and nutrient content of potash fertilizers

Plan d'essai et teneur en éléments nutritifs des engrais potassiques

begin: 1913/14

trial plan:
- K_0
- kainite
- KCl (40% K_2O)
- KCl (50% K_2O)
- K_2SO_4

parallels: at beginning 6 à 25 m^2; later on 3 à 25 m^2

liming (kg CaO/ha):
- 1932 275 as $CaCO_3$
- 1935 1200 as $CaCO_3$
- 1944 700 as $Ca(OH)_2$

average nutrient content (%) of potash fertilizers				
K	Cl	SO_4	Mg	Na
10.4	43	15	4	22
33.2	43	9	2	8
41.8	45	4.5	1	4
41.1	0.5	54	0.5	0.1

(according to communications of Agricult. Chem. Station Stuttgart and our own investigations)

No manure was applied during the whole period.

Especially by continous kainite fertilization very high amounts of Cl and Na and amounts of SO_4 equal to K_2SO_4 have been applied.

The rotation corresponds fairly with a so called three-course system : root crops-cereals-cereals.

The most frequent crops and the average amounts of NPK applied per year are listed up in table 4.

TABLE 3

Applied amounts of secondary constituents from 1914-1975
kg/ha

K - form	Cl	SO_4	Mg	Na
kainite	22 300	7 800	2 100	11 400
KCl (40% K_2O)	7 000	1 500	330	1 300
KCl (50% K_2O)	5 800	600	130	500
K_2SO_4	70	7 100	70	10

TABLE 4

Cultivated crops and amounts of fertilization
Cultures et quantités en éléments fertilisants

cultivated crops 1914-1975	years	average annual fertilizer doses (kg/ha)		
		N	P	K
winter resp. summer wheat	11	56	28	66
winter rye	2	30	27	62
oats	3	60	32	72
winter resp. summer barley	13	36	24	63
potatoes	11	77	28	94
beets (fudder or sugar)	7	111	45	133
maize	3	83	35	108
legumes, rape, vegetable crops etc.	9	69	37	113

RESULTS

Dry matter production of crops (table 5)

In the NPK plots between 5 400 and 5 500 dt dry matter/ha have been produced after 59 crops compared with 4 500 dt/ha in the control. This is adequate to not much more than 90 dt dry matter/ha and year, respectively 76 dt/ha in the plots without K and to an average potash uptake between 115 and 126 respectively 77 kg K/ha and year.

TABLE 5

Total dry matter production and K-uptake 1914 - 1975 (59 crops)

Production en matière sèche totale et K absorption 1914 à 1975 (59 cultures)

K-form	yield dt dr.m./ha Σ	yearly	uptake kg K/ha Σ	yearly	fertilization kg K/ha Σ	yearly	utilization rate of K-fertilization %	K-uptake — K-fertilization kg K/ha Σ	yearly
K_o	4508	76.4	4531	76.8	–	–	–	4531	76.8
kainite	5381	91.2	6803	115.3	5127	86.9	44	1676	28.4
KCl (40% K_2O)	5517	93.5	7269	123.2	5127	86.9	53	2142	36.3
KCl (50% K_2O)	5511	93.4	7410	125.6	5127	86.9	56	2283	38.7
K_2SO_4	5399	91.5	7039	119.3	5127	86.9	49	1912	32.4
CD 5%	222	3.9	490	8.6					

TABLE 6

Mineral contents in plant material (% i. dry matter)

K-form	sugar beets							
	beets				leaves			
	K	Na	Ca	Mg	K	Na	Ca	Mg
K_o	0.91	0.10	0.16	0.16	2.81	1.91	1.32	0.70
kainite	0.93	0.14	0.14	0.15	3.43	3.51	0.95	0.45
KCl (40% K_2O)	0.98	0.09	0.15	0.16	3.73	3.15	1.03	0.52
KCl (50% K_2O)	0.96	0.06	0.14	0.15	3.57	2.22	1.20	0.62
K_2SO_4	0.94	0.06	0.15	0.15	3.66	1.74	1.11	0.50
CD 5%	0.10				0.32			

K-form	potatoes				cereals					
					grains			straw		
	K	Na	Ca	Mg	K	Ca	Mg	K	Ca	Mg
K_o	1.73	0.02	0.06	0.09	0.50	0.07	0.13	0.75	0.35	0.08
kainite	2.24	0.03	0.05	0.08	0.52	0.07	0.12	1.07	0.26	0.07
KCl (40% K_2O)	2.35	0.01	0.05	0.09	0.52	0.06	0.12	1.14	0.28	0.07
KCl (50% K_2O)	2.79	0.01	0.05	0.09	0.53	0.06	0.12	1.16	0.28	0.07
K_2SO_4	2.42	0.01	0.05	0.11	0.54	0.07	0.13	1.10	0.30	0.07
CD 5%	0.38				0.08	0.02	0.005	0.08	0.02	0.002

The average annual fertilization rate of 86.9 kg K/ha was utilized by kainite only with 44 p. 100, by potassium sulfate resp. chlorides not higher than with 49-56 p. 100 because of a relatively high K delivery from the soil.

Within the whole period 4 531 kg K/ha were delivered from the soil reserve to crops without K fertilization. However in the NPK plots the total K uptake by plants ranged between 6 800 and 7 400 kg/ha and was covered by fertilizer K only to about 70 p. 100 ; consequently the rest, that means 28-40 mg K_2O/100 g soil (up to 45 cm depth) came from the soil.

As to the different fertilizer forms, both potassium chlorides obtained the highest dry matter production and K-uptake, whereas kainite and potassium sulfate showed more or less lower results. This good response of highly concentrated KCl-fertilizers may be a matter of the easy uptake of K^+ and Cl^- compared with SO_4^{--} ; however the high salt content of kainite (see table 2) deteriorated soil properties (see later) and depressed yields.

The *potassium content* (table 6) of plants well dressed with K is very low in grains (Ø 0.5 p. 100 i. dry matter) ; in beets and straw it ranges between 0.9 and 1.1 p. 100, but is very high in potato tubers (ca. 2.5 p. 100) and sugar beet leaves (ca. 3.6 p. 100). Plants suffering from K deficiency show much lower figures.

TABLE 7

Average yearly yields (dt dry matter/ha), K uptake (kg K/ha) and utilization of K (%)

Rendement moyen annuel (dt mat. sèche/ha), absorption (kg K/ha) et utilisation de K (%)

K-form	potatoes			sugar beets			maize		
	yield	K-uptake	K-utilization	yield	K-uptake	K-utilization	yield	K-uptake	K-utilization
	94 kg K/ha x)			133 kg K/ha x)			108 kg K/ha x)		
Ko	40.4	74	–	151.6	195	–	94.2	71	–
kainite	66.1	161	92	186.0	262	50	123.3	115	41
KCl (40% K_2O)	72.2	181	114	183.8	268	55	125.1	115	41
KCl (50% K_2O)	73.0	182	116	187.6	277	61	112.0	117	43
K_2SO_4	72.4	180	113	189.2	259	48	124.3	124	49
CD 5%	6.6	23.5		12.6	24.5		21.3	35.0	
	wheat			barley			oats		
	yield	K-uptake	K-utilization	yield	K-uptake	K-utilization	yield	K-uptake	K-utilization
	66 kg K/ha x)			63 kg K/ha x)			72 kg K/ha x)		
Ko	92.6	57	–	66.8	42	–	75.8	78	–
kainite	100.8	79	34	75.4	61	31	74.5	90	17
KCl (40% K_2O)	104.6	86	45	76.4	63	33	79.6	107	40
KCl (50% K_2O)	106.6	89	49	75.6	63	33	79.7	109	43
K_2SO_4	104.4	82	38	72.2	57	23	80.9	109	43
CD 5%	5.8	10.2		3.4	4.8		5.2	10.4	

x) = average yearly fertilization

The *sodium content* is very low in potatoes, but in sugar beet leaves it is nearly as high as potassium ; the sodium level is influenced by potash fertilizers on behalf of their different sodium content (see table 2).

Generally, the plants from the control plots show little higher *Ca and Mg contents* compared with those well supplied with potassium.

Response of crops on potash fertilization :

Among the main cultivated crops *potatoes* gave the maximum response on potash fertilization (table 7), that means an increase of about 64 p. 100 in case of kainite and even 80 p. 100 of all the other K fertilizers. Similar results are reported by KICK and POLETSCHNY (1975).

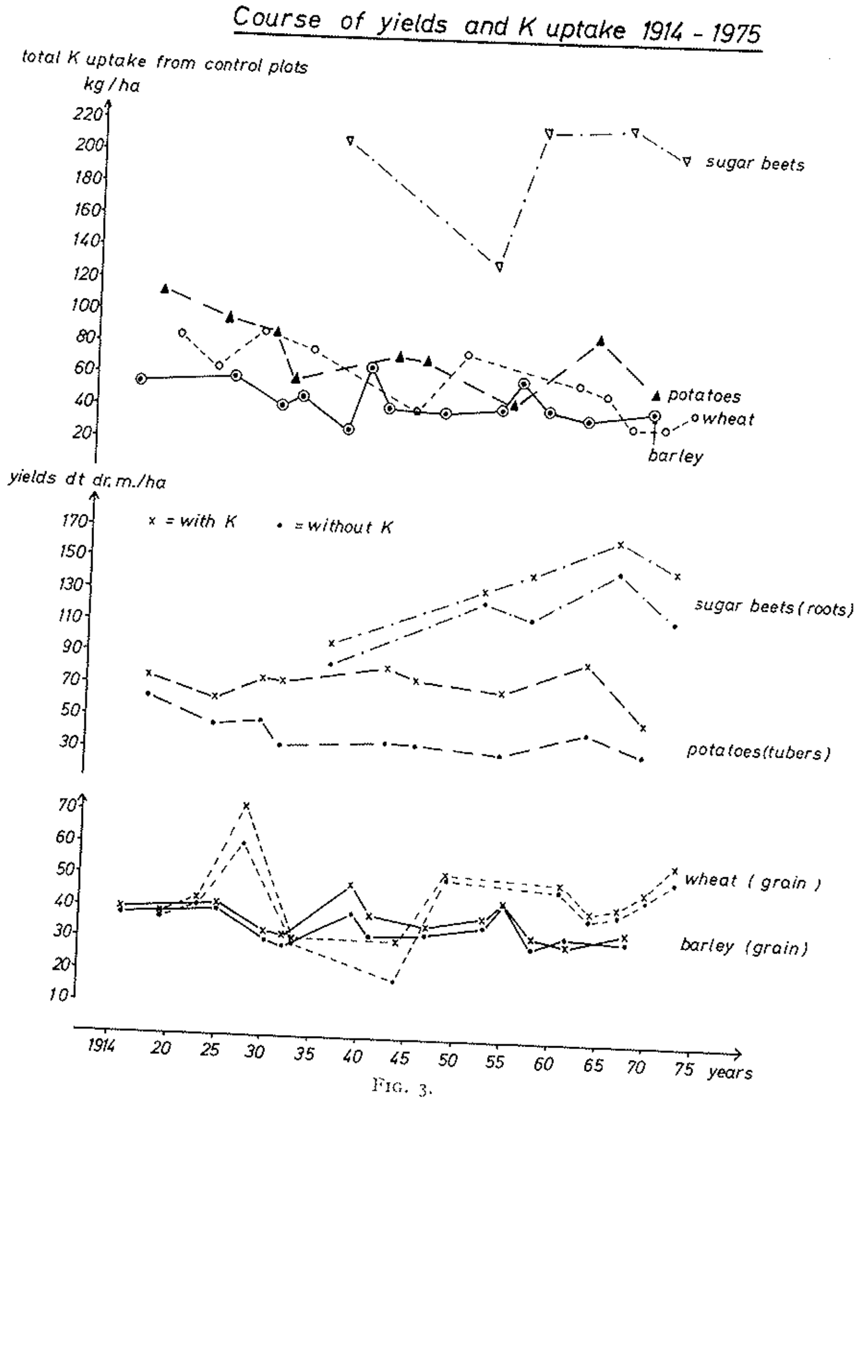


FIG. 3.

The average annual fertilization of 94 kg K/ha as highly concentrated forms has been utilized completely. Sugar *beets* dressed with potash, increased the yields by 23 p. 100 (without any marked difference between the K-forms) and utilized the mineral K at a rate of 48-61 p. 100 (at the best from the highly concentrated potassium chlorides, at the lowest from potassium sulfate).

Maize answered on mineral K fertilization with an increased dry matter production of about 30 p. 100, *wheat* and *barley* with 10-14 p. 100, whereas *oats* did not attend more than 5 p. 100, depending on the potash form in each case. The concentrated potash fertilizers have been utilized with 44 p. 100 by wheat, 42 p. 100 by oats and 30 p. 100 by barley. Kainite, nowadays a not very common K fertilizer reached always considerably lower results because of its high salt content.

The total K uptake from the usual chloride resp. sulfate forms ranged between 50 (barley) and 117 (maize) among the cereals and between 181 (potatoes) and 270 (sugar beets) kg K/ha and year among the dicots.

The question is now : how do run the yields and K uptake in + K and — K plots within 60 years?

According to figure 3 the highly K-intensive potatoes show slowly decreasing yields and potassium uptake in the controls ; obviously the soil potassium will run more slowly with time. The K uptake of wheat and barley is very similar however this slowly dropping removal of soil K does not affect the yields of these crops yet.

Among the dicots sugar beets show the highest ability of utilizing soil K (195 kg K/ha), oats (78 kg K/ha) and wheat (57 kg K/ha) surpass the other cereals.

Generally *the quality* of crop products was improved by potassium supply (table 8), that is for instance kernel weight and percentage of full kernels for wheat and barley, starch and sugar contents of potatoes resp. sugar beets. Consequently higher amounts of starch and sugar/ha were achieved.

TABLE 8

Quality of crop products as affected by potassium

Influence du potassium sur la qualité des cultures

K-form	wheat		barley		potatoes		sugar beets	
	thousand kernel weight g	percentage of kernels > 2.5mm ⌀	thousand kernel weight g	percentage of kernels > 2.5mm ⌀	starch % in fresh weight	starch dt/ha	sugar % in fresh weight	sugar dt/ha
K_0	34.9	83.5	42.6	90.0	17.0	32.2	19.9	112
kainite	41.0	90.2	43.4	92.0	16.3	53.8	20.3	124
KCl (40% K_2O)	42.0	89.2	43.6	92.2	17.5	60.7	20.4	127
KCl (50% K_2O)	41.6	90.5	43.4	92.1	17.5	61.2	20.2	123
K_2SO_4	41.4	91.0	42.9	92.7	18.0	64.3	20.2	122
CD 5 %	1.1	4.0	0.7	1.3	4.2	4.2	0.7	7.0

Because of the high chloride content of kainite resp. potassium chlorides their permanent application depressed starch content and starch yields of potatoes evidently compared with the positive effect of the potassium sulfate.

Soil

The pH in the top soil, starting from approximately 6.0 was not affected at all by continuous potash application within 60 years (fig. 4). However several limings resulted in definite peaks, which subsequently slipped down to a more or less higher constant level.

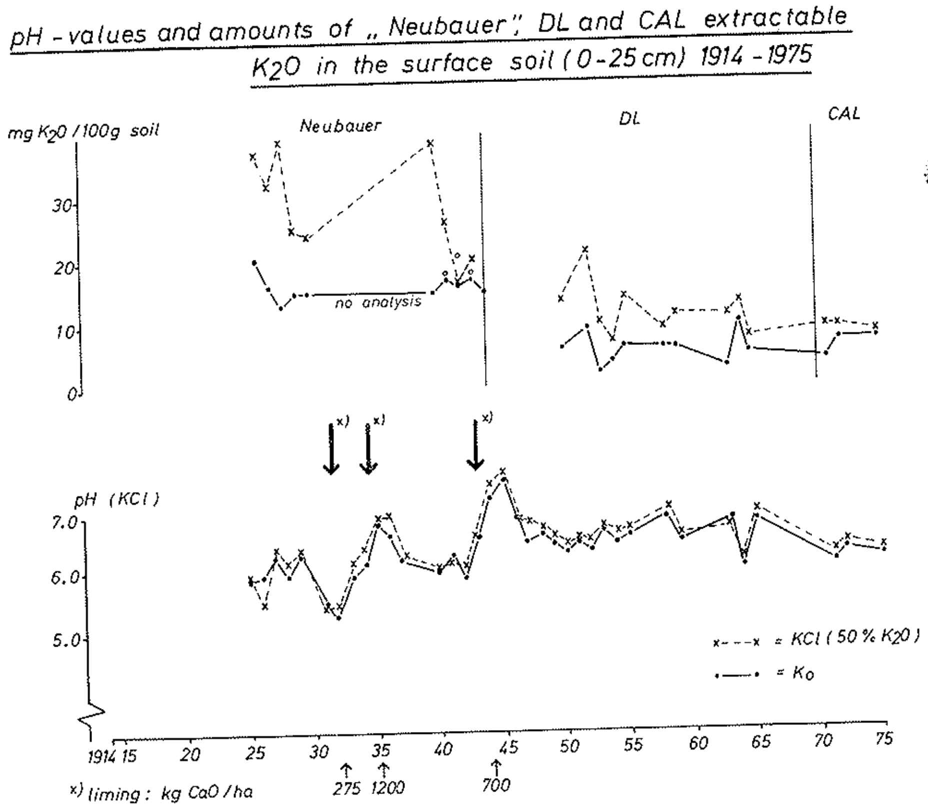


FIG. 4.

Potassium extractable by DL (= double lactate) respectively CAL (= calcium acetate lactate), differentiated fairly well between K_0 and KCl (50 p. 100 K_2O), however even after a normal potassium supply over 60 years the CAL values were not affected very much and did not exceed 10 mg K_2O/100 g soil finally. The control values remained nearly constant (6-7 mg DL-K_2O or about 16 mg Neubauer — K_2O/100 g soil) respecting the different methods for available K, inspite of an average yearly potassium removal of approximately 81 mg K_2O/100 g soil (see also SCHRÖDER, 1955).

Final investigations (autumn 1975) on K-dynamics in the soil profil (table 9) showed in the CAL-K and HCl-K minus CAL-K values (SCHACHTSCHABEL, 1961) only little differences between the — K and + K plots (independant from the K forms) in the whole profile, although very high K removals took place within the last 60 years.

TABLE 9

Effect of a long-term K - fertilization on CAL-K, HCl-K, K wet fixation and cation sorption

depth cm	K - form	total K	CAL-K *)	HCl-K **) − CAL-K	wet fixation	TEC °)	CEC °°)	Na	K	Ca	Mg	V °°°)
		%	mg K/100g soil			meq/100g soil						%
0-15	without K	1.59	6	26	22	14.2	13.7	0.02	0.14	12.4	1.14	96
	kainite	1.51	8	27	0	11.1	10.9	0.18	0.20	9.2	1.34	98
	K_2SO_4	1.55	7	30	8	11.8	11.1	0.08	0.15	10.1	0.81	94
15-30	without K	1.58	6	26	22	13.4	12.8	0.01	0.13	11.6	1.07	96
	kainite	1.53	5	18	22	10.5	10.5	0.49	0.08	8.7	1.27	100
	K_2SO_4	1.65	7	29	15	13.0	11.7	0.03	0.13	10.6	0.89	90
30-45	without K	1.56	7	29	23	13.2	11.3	0.03	0.16	9.1	1.99	85
	kainite	1.47	5	20	16	8.4	8.4	0.30	0.09	7.2	0.76	100
	K_2SO_4	1.66	7	25	31	12.0	11.1	0.02	0.12	10.0	0.99	93

*) = Calcium acetate lactate
**) = soluble in 1n HCl

°) TCE = total exchange capacity
°°) CEC = cation exchange capacity
°°°) V = base saturation

Also the small numerical differences of total K are within the analytical error of these methods and do not allow further conclusions. However the wet fixation (SCHACHTSCHABEL, 1961) was very much lowered after a long-term supply with chloride or sulfate forms ; it even disappeared completely in case of kainite. The top soil of the K_0-plots maintained the same fixation capacity as the subsoil layers.

The *total exchange capacity* was the highest in the controls and decreased markedly by long-term kainite application. The K sorption on total exchange capacity was nearly the same both in the — K and + K plots and did not change practically in the whole profil. Ca and Mg sorption was definitely higher in the controls than in the concentrated K-form plots down to 45 cm depth regularly.

The sodium sorption was extremely raised by long-term kainite application and even increased in deeper layers, which demonstrates the high mobility of sodium in the profil. Also Mg sorption was elevated by kainite, consequently the base saturation increased up to 100 p. 100 of total exchange capacity.

DISCUSSION AND CONCLUSIONS

The loess and tertiary material of this location is fairly rich of potassium (= 105 000 kg K/ha down to 45 cm depth). Obviously this K reserve can be mobilized relatively easily by the most plants, although the level of the available K remains low (7 mg CAL-K_2O/100 g soil).

The cultivated crops have specific potassium requirements and specific abilities for mobilizing soil K (cereals and sugar beets at the best, potatoes at the lowest).

A potassium balance in the soil (table 10 and table 5) after 60 years shows that in case of K_0 4 500 kg K/ha have been withdrawn from the soil reserve (that is 67 mg K/100 g soil down to 45 cm depth) and between 1 700 and 2 300 kg K/ha more from the plots supplied regularly with potash fertilizers (corresponding to 24-34 mg K/100 g soil in 45 cm depth).

TABLE 10

K balance 1914 - 1975

Bilan de K 1914 à 1975

K-form	K removal from soil 1914-1975			1975	
	kg K/ha	calc. to 45cm depth	difference to K_0	calc. to 45 cm depth CAL	K wet fixation
		mg K/100g soil			
K_0	4531	67	—	6	23
kainite	1676	24	43	6	13
KCl (50% K_2O)	2283	34	33	7	7
K_2SO_4	1912	28	39	7	11

However these very big differences in K uptake between — K and + K will hardly be expressed by CAL- or DL-values ; moreover the very small differences between — K and + K plots will not be enlarged even after 60 years K fertilization and confirm the results of v. BOGUSLAWSKI and LACH (1971) and RICHTER (1975). With regard to a clay content of 16 p. 100, obviously a K concentration of 0.35 mg CAL-K/g clay is typical for this loess location. It cannot be lowered permanently by plant uptake appart from changes within a vegetation period ; because of a fairly fast flow from native K to available K an equilibrium always stabilizes. Also ZEHLER (1959), SCHEFFER *et al.* (1960) resp. FEIGENBAUM and KAFKAFI (1972) come to similar conclusions. Obviously these methods are too rough to render differences like those in soil potassium adequate to a total removal of 81 mg K_2O/100 g soil in a depth of 45 cm within 60 years. This is not very much more than 1 mg K/100 g soil (calculated to 45 cm depth) or 76 kg/ha and year, which is delivered from native K by a permanent flow.

The best answer till gave the potassium wet fixation : after continuous potash supply it disappeared practically at all (see also WELTE and NIEDERBUDDE, 1965).

The difference between — K and + K are 10-16 mg K/100 g soil (to 45 cm depth) respect. 700-1 100 kg K/ha. Both, the positive difference in CAL-K and the decreasing fixation capacity by K fertilization makes up approximately 1 100 kg K/ha all in all. However this is adequate only to about 1/3 of the calculated removal from plants well dressed with K or 1 p. 100 of total K of 45 cm top soil respectively 0.01 p. 100 K in the soil. However this difference lies within the margin of the analytical and sampling error over such a long period.

Consequently, all the chemical methods used here are not appropriate enough to explain the results of this field trial and therefore cannot replace the plant experiment. Some more specific investigations are necessary to elucidate the K dynamics of this location.

Reçu pour publication en mai 1976.

RÉSUMÉ

EFFET D'UNE FERTILISATION POTASSIQUE DE LONGUE DURÉE SUR LES RÉCOLTES ET SUR LA DYNAMIQUE DU POTASSIUM DANS UN SOL BRUN (WEIHENSTEPHAN)

Dans un essai de longue durée (60 ans), on a examiné l'influence d'engrais potassiques (KCl à 40 et 50 p. 100 de K_2O, K_2SO_4 et kaïnite) sur les rendements et l'absorption du potassium par différentes cultures ainsi que sur la dynamique de K dans un sol brun, de pH 6,3, contenant 1,6 p. 100 K total.

Il y avait une différence d'environ 1 000 d t/ha dans la production totale de matière sèche et de 2 500 à 3 000 kg/ha dans l'absorption du potassium par les cultures, entre les parcelles — K et + K. Le degré d'utilisation des différents engrais potassiques variait de 40 à 50 p. 100, les meilleurs résultats ayant été obtenus avec le KCl sous la forme la plus concentrée et les plus faibles avec la kaïnite.

La teneur des plantes en potassium a été augmentée significativement par les engrais potassiques, particulièrement dans les organes végétatifs. Les pommes de terre réagissaient le plus fortement à la fertilisation potassique (augmentation de rendement de 60 à 80 p. 100) alors que le blé et l'orge présentaient la plus faible réaction (augmentation de rendement de 10 à 14 p. 100).

L'absorption totale annuelle du potassium par les différentes cultures se situaient entre 60 (pour l'orge) et 270 kg K/ha (pour la betterave sucrière).

Dans tous les cas, la qualité des plantes a été améliorée.

On n'a pas constaté de changement dans le pH des sols après 60 ans de fertilisation potassique. Les sols des parcelles sans K et avec K ont été assez bien différenciées par les méthodes d'extraction DL (ou double lactate) et au CAL (calcium acétate lactate) ; mais après cette longue période love fertilisation, les teneurs en CAL-K et DL-K étaient inférieures à 10 mg K_2O/100 g de sol et ne rendaient pas compte de l'importante libération du K du sol par les témoins.

Après application prolongée de kaïnite, on pouvait observer une diminution de la capacité d'échange du sol ainsi qu'une forte augmentation du sodium échangeable dans toutes les couches du sol. Quant aux taux de K échangeable des sols des parcelles avec K et sans K, ils étaient semblables mais les teneurs en Ca et Mg échangeable des témoins étaient plus élevées.

ZUSAMMENFASSUNG

WIRKUNG EINER LANGJÄHRIGENKALIDUNGUNG AUF ERNTEERZEUGNISSE UND KALIUMDYNAMIK EINER BRAUNERDE (WEIHENSTEPHAN)

In einem Dauerdüngungsversuch (60 Jahre) wurde der Einfluss verschiedener Kalidünger (KCL mit 40 p. 100 und 50 p. 100 K O, K SO und Kainit) auf die Ernteerträge und die Kaliumaufnahme durch verschiedenen Kulturen, sowie die Kaliumdynamik in einer Braunerde (Gesamt-Kalium 1,6 p. 100, pH 6,3) studiert.

Ein Unterschied von ungefähr 1 000 dt/ha in der gesamten Trocken — substanzerzeugung und von 2 500-3 000 kg/ha in der Kaliumaufnahme durch die Kulturen liess sich zwischen de — K und + K Parzellen feststellen. Die einzelnen Kalidüngesalze wurden zu etwa 40-50 p. 100 ausgenützt, wobei die besten Ergebnisse mit KCL Dünger und die schwächsten mit Kainit erhalten worden waren.

Die Anwendung von Kalidüngern führte zu einer erheblichen Erhöhung des Kaliumgehaltes der Planzen, besonders in den grünen Organen. Die Wirkung der Kalidünger war bei Kartoffeln am höchsten (60-80 p. 100 Ertragserhöhung), bei Weisen und Gerste am niedrigsten (10-14 p. 100 Ertragserhöhung).

Die jährliche Gesamtaufnahme an Kalium durch die verschiedenen Kulturen erreichte 60 (Gerste) bis 270 (Zuckerrübe) kg K/ha.

In allen Fällen konnte man eine Verbesserung der Qualität der planzlichen Produkte beobachten.

Keine Veränderungen der pH-Zahl der Böden konnten nach 60 jähriger Kalidüngung festgestellt werden. Durch die Extraktionsmethoden DL (Doppellaktat) und CAL (Calcium-Azetat-Laktat) wurden die Böden der Parzellen mit K und ohne K gut abgegrenzt ; aber die Gehalte an CAL-K und DL-K erreichten nicht 10 mg K 0/100 g Böden nach dieser Dauerdüngung und konnten auch den erheblichen K-Entzug aus dem Böden der Kontrolle nicht darstelle:

Nach langjährigem Einsatz von Kainit war eine Verringerung der Gesamtauschkapazität, sowie eine beachtliche Erhöhung des in allen Bodenschichten adsorbierten Natriums festzustellen. Beide Parzellen (mit oder ohne K) zeigten ähnliche Gehalte an austauschbarem K, doch waren die Gehalte an austauschbarem Ca und Mg in den Kontrollen höher.

РЕЗЮМЕ

Влияние длительного применения калийных удобрений на урожаи, и на динамику калия в коричневой почве (Вейгенстефан).

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Влияние калийных удобрений (KCl содержавшего 50 % K_2O, K_2SO_4 и каинита) на урожайность, поглощение калия разными культурами, и динамику калия в коричневой почве (pH — 6,3), содержащей 1,6 % общего калия, изучалось в долгосрочном опыте (60 лет) :

— В общей продукции сухого вещества отмечена разница в приблизительно 1 000 тонн/га и в поглощении калия культурами — разница в 2 000 — 3 000 кг/га между делянками — K и + K. Степень потребления разных калийных удобрений изменялась от 40 до 50 % и наилучшие результаты получены были при применении наиболее концентрированных форм KCl, а результаты самые слабые — при применении каинита.

— Применение калийных удобрений увеличивало содержание элемента в растениях и особенно в их вегетативных органах. Картофель реагировал сильнее других культур на внесение калия (увеличени урожая на 60 — 80 %), в то время как реакция пшеницы и ячменя была наиболее слабой (увеличение урожая на 10 — 14 %). Суммарное поглощение калия разными культурами за год изменялось от 60 (ячмень), до 270 кг/га (сахарная свекла). Во всех случаях качество растений улучшалось.

— После 60-ти летнего внесений калийных удобрений не отмечалось никакого измения pH почвы. Для экстракций из почв делянок — K и + K применялись 2 разных метода: DL (двойной лактат)

и CAL (кальций, ацетат, лактат); но по истечении длительного периода внесения удобрений содержание K-CAL и K-DL не достигало 10 мг K_2 0/100 гр. почвы и делянки эти не освобождали те крупные количества почвенного калия какие освобождались контрольными делянками.

После длительного применения каинита наблюдались ослабление обменной способности почвы и сильное увеличение поглощения натрия во всех слоях почвы. Что-же касается процента обменного калия, он был одинаков в почвах делянок — K и + K, но контрольные делянки содержали больше Ca и Mg.

REFERENCES

BOGUSLAWSKI E. von, LACH G., 1971. Die K-Nachlieferung des Bodens im Pflanzenexperiment im Vergleich mit dem austauschbaren Kalium. *Z. Acker- und Pflanzenbau*, **134**, 135-164.

FEIGENBAUM S., KAFKAFI U., 1972. The effect of illite content in soils on the potassium supply to plants. *9th IPI-Colloquium : Potassium in soil.* Landshut, Germany, July 11th to 13th.

HANDBUCH DER LANDWIRTSCHAFTLICHEN VERSUCHS- UND UNTERSUCHUNGSMETHODIK, 1955. Band I : *Die Untersuchung von Böden — Neumann Verlag*, Radebeul und Berlin, 3. Auflage.

HARTGE K. H., 1971. *Die physikalische Untersuchung von Böden.* Ferd. Enke Verlag, Stuttgart.

KICK H., POLETSCHNY H., 1975. Kaliumhaushalt und Ertragsleistung bei einem langjährigen Kaliformenversuch. *Landw. Forschung*, **31**/1.Sh. 59-68.

RICHTER D., 1975. Probleme der Charakterisierung des pflanzenverfügbaren Kaliums in Ackerböden. *Arch. Acker- u. Pflanzenbau und Bodenkunde*, Berlin, **19**, 475-485.

SCHACHTSCHABEL P., 1961. Fixierung und Nachlieferung von Kalium- und Ammonium-Ionen — Beurteilung und Bestimmung des Kalium-Versorgungsgrades von Böden. *Landw. Forsch.*, **14**, 15.Sh, 29-47.

SCHEFFER F., WELTE E., GRAF V. REICHENBACH H., 1960. Über den Kaliumhaushalt und Mineral, bestand des Göttinger E-Feldes. *Z. Pflanzenernährung, Düngung, Bodenkunde*, **88**, 115-128.

SCHROEDER D., 1955. Kaliumfestlegung und Kaliumnachlieferung von Lössböden. *Landw. Forschung-* **8**, 1-7.

SCHÜLLER H., 1969. Die CAL-Methode, eine neue Methode zur Bestimmung des pflanzenverfügbaren Phosphates in Böden. *Z. Pflanzenernährung, Düngung, Bodenkunde*, **123**, 48-63.

WELTE E., NIEDERBUDDE E. A., 1965. Fixation and availability of potassium in loess derived and alluvial soils. *J. Soil Sci.*, **16**, 116-120.

ZEHLER E., 1959. *Die Kalium-Nachlieferung und Kaliumfixierung von Lössböden statischer Düngungsversuche.* Diss. T. H. Hannover.