WATER CONSUMPTION AND STUFF DISCHARGE AFTER CONVERSION OF ARABLE FARM LAND INTO GRASSLAND AND IN THE CASE OF NATURAL SUCCESSION

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Introduction

After the political change in 1989 extensive conservation was carried out on a grand scale in the federal states of former East Germany. This included set-aside measurements of agricultural land, change of utilization and withdrawal of fertilization, cultivation and utilization. Arable farm land on erosion-endangered and especially on lighter sandy soils in the areas of north-eastern Germany are now converted into grassland or are partly released into natural succession. While observing this conversion it is not only necessary to keep an eye on the desired reduction of agricultural products, but also to consider the multi-functionality of land use in general. This mainly includes problems of reshuffling underground water, the dynamic of substance discharge, changes of landscape scenery and not least socio-economical aspects. With the help of the submitted lysimeter investigations it was to clarify which differences in water consumption and substance discharge are caused by different variants in the change of utilization – arable farm land - grassland (succession).

Material and Methods

Examined were two wide-spread types of soil in northeastern Germany: (a) Dystric gleysol and (b) Eutric fluvisol. They are situated in monolytic extracted lysimeters with a surface of 1 m² and a depth of 1.5 m. The following soil parameters are available:

Soil parameter	**Depth of soil (cm)**			
	0 – 24	**24 – 55**	**65 – 80**	**80 -120**
a) bulk density g/cm³	1.58	1.62	1.73	1.74
pH	3.7	4.4	4.4	5.5
org. substance %	1.72	0.41	0.58	0.17
b) bulk density g/cm³	2.07	1.76	1.83	1.58
pH	5.3	5.2	5.4	7.8
org. substance %	0.70	0.41	0.33	-

The fields were set-aside i.e. the utilization was changed after several years of growing silo maize, in the years 1992-1994. The typical hydromorphic soils on sites in north-eastern Germany were originally used as grassland. Later, in the course of intensification, these sites were ploughed. They were often used for cultivation of maize, which strongly contributed to the reduction of organic substance in the soil. The following types of utilization were compared (since 1995):

- Natural overgrowth of grass combined with utilization after set-aside;
- Overgrowth of shrubs after set-aside due to omission of utilization (natural succession);
- Sowing of permanent grassland; and
- Cultivation of oats with grass-underseed.

Investigated were the development of botanical composition according to the extension of covering (System BRAUN-Blanquet), above ground biomasse yields, substance discharge into underground water, water consumption according to different criteria and substance balances (macro-elements).

Type of Utilization		**1**	**2**	**3**	**4**
Fertilization	N	60	-	60	60
kg/ha	P	40	-	40	40
elemental nutrients	K	120	-	120	120

Results and Discussion

The results have to be interpreted keeping in mind that the soils can be considered as relatively weakly underground water influenced with a standard groundwater level of 90 cm. Therefore the weather factors have a

special importance, as the yearly water balances on the basis of the hydrological year also show (Table 1). The water demands in the period between October and September are mainly visible by inflow. In order to maintain the underground-water level of 90 cm, water has to be continually supplied (subirrigation). Here it becomes clear, that the grass variants (1, 3, 4) on both kinds of soil differ only very little. However, overgrowth of shrubs needs significantly higher subirrigation of water, which especially indicates deeper rooting in the soil. Looking at discharge the variants only differ very little, merely on Dystric Gleysol discharge is reduced more due to overgrowth of shrubs.

Altogether it is recognisable, that overgrowth of shrubs (natural succession) empties the natural water supply enormously. With mean rainfall of 514 mm on the site Paulinenaue over many years, underground water regeneration is only possible with grass variants (Schalitz 2001). Overgrowth of shrubs and the following development of woodland contribute already medium-term to exhaustion of existing underground water reserves. The overgrowth of shrubs at site Decksalm (Eutric Fluvisol) was especially unfavourable, which can be attributed to the quick growth of willow shrubs. On Dystric Gleysol growth of shrubs developed more slowly. After long-time growth of shrubs a similar negative water balance as at Eutric Fluvisol has to be expected.

Above ground biomass yields and the specific water consumption are presented in table 2. Reference period is the vegetation period between April and October of each experimental year. It is conspicuous that during the five experimental years above ground dry weight (DM) has been built less by shrubs than by sowed grasses or by natural overgrowth of grasses or herbs. At the same time water consumption of shrubs was significantly higher. This is leading to the conclusion that the specific water use efficiency (WUE) of shrubs is considerably less favourable. All grass variants were considerably under 1000 mm/kg DM, while overgrowth of shrubs needed nearly double the amount. So with overgrowth of shrubs the ecosystem loses more water on the one hand, and on the other hand the water is less favourably used. Therefore, with the goal of regeneration of underground water in regions with little rainfall, overgrowth of shrubs resp. reforestation should not be allowed in a big scale.

After set-aside natural overgrowth of grass/herbs was less favourable in water balance and water use efficiency than the sowed variants. First mentioned variants delivered fodder, which was rated at the limit of eatability (≤ 500 EFr/kg DM = 500 Energetic feed equivalents per kg of dry matter). The best water use efficiency was shown by the seed variant with grass mixture under oats, because it was superior to the yield of pure seed. In fodder quality the grass mixture under oats and pure seed both performed similarly positive (≥ 530 EFr/kg DM). According to the farming use conception fodder can be used as pasture or cutting material.

Conclusion

When acre sites under conditions of north-eastern Germany are left to overgrowth of shrubs, the water supply of the soil will be completely exhausted and underground water regeneration will not take place anymore. Natural overgrowth of grass combined with utilization also contributes to relatively unfavourable water balances with a fodder quality, which leads to hardly sufficient animal productivity. It would be suitable to specifically sow the set-aside-areas with grass mixtures. Among those underseed under green oats was the most favourable variant.

References

Schalitz, G. (2001). Versuchsführer, Forschungsstation Landwirtschaft des ZALF, Müncheberg, Standort Paulinenaue, 63 p

Table 1. Yearly water balances (basis: hydrological year)

Lysimeter No.	Variant	Year (X-IX)	Rainfall mm	Recharge mm	Discharge mm	Balance mm
Eutric Fluvisol						
88	1	1994/95	598	156	316	438
	Naturally overgrowth of grass combined	1995/96	353	125	53	425
	with utilization after a set-aside	1996/97	378	245	166	457
		1997/98	487	225	172	540
		1998/99	522	291	286	527
mean			468	208	199	477
94	2	1994/95	598	178	313	463
	Overgrowth of shrubs after a set-aside	1995/96	353	336	90	599
	in connection with failure of utilization	1996/97	378	938	124	1192
	(natural succession)	1997/98	487	564	154	897
		1998/99	522	160	280	402
mean			468	435	192	711
90	3	1994/95	598	160	355	403
	Sowing of permanent grassland	1995/96	353	158	112	399
		1996/97	378	198	152	424
		1997/98	487	164	173	478
		1998/99	522	165	290	397
mean			468	169	216	420
92	4	1994/95	598	112	115	595
	Cultivation of oats in combination with	1995/96	353	142	78	417
	an underseed of grass	1996/97	378	243	168	453
		1997/98	487	170	172	485
		1998/99	522	158	282	398
mean			468	165	163	470
Dystric Gleysol						
89	1	1994/95	598	106	287	417
	Natural overgrowth of grass combined	1995/96	353	111	93	371
	with utilization after a set-aside	1996/97	378	205	117	466
		1997/98	487	120	113	494
		1998/99	522	113	254	391
mean			468	131	173	428
95	2	1994/95	598	196	294	500
	Overgrowth of shrubs after a set-aside	1995/96	353	199	68	484
	in connection with failure of utilization	1996/97	378	269	62	585
	(natural succession)	1997/98	487	140	39	588
		1998/99	522	47	143	426
mean			468	170	121	517
91	3	1994/95	598	87	321	364
	Sowing of permanent grassland	1995/96	353	74	81	346
		1996/97	378	150	84	444
		1997/98	487	145	109	523
		1998/99	522	104	282	344
mean			468	112	175	404
93	4	1994/95	598	121	278	441
	Cultivation of oats in combination with	1995/96	353	93	92	354
	an underseed of grass	1996/97	378	136	66	448
		1997/98	487	81	48	520
		1998/99	522	147	242	427
mean			468	116	145	438

Table 2. Yields and specifically water consumption in experimental years 1995–1999

Lysimeter No.	Variant-No.	Balance IV – X mm	Yield kg DM/m²	Specific water consumption mm/kg DM
Entric Fluvisol				
88	1	2165	2.346	922
94	2	3473	1.940	1790
90	3	1974	2.287	863
92	4	2054	2.442	841
Dystric Gleysol				
89	1	1905	2.229	854
95	2	2190	1.463	1496
91	3	1806	2.355	766
93	4	1850	2.834	652