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RESULTS OF INVESTIGATIONS OF AN EXPERIMENT AIMING AT THE DEVELOPMENT OF BIOLOGICAL DEFENCE AND PRODUCTIVITY OF GRASS ASSOCIATIONS ON THE TISZA DAM, IN THE ENVIRONMENT OF SZEGED

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The detailed tasks of the blueprint of biological work realized so far by the Tisza Research Society, resp. the results of its research work, are affording us such a review of the biotop of the river and environs, and inside it of the flora we are interested in, that the material of knowledge reflecting some detailed results of these like, for example, the composition and synecological conditions of the grass associations of dams, may approach even the solution of some questions raised by practical specialists. One of them is to influence the plant species, forming the grass cover of dams, in such a way that they assure in a higher degree the biological defence of dams in case of floods. Within the scope of our research programme we are anyway pleased to deal with phytocenologico-synecological problems of the Tisza dams because the water vegetation of woods, meadows and meanders in the flood area is disturbed by the more and more increasing influence of culture to such an extent that the ancient vegetation is forced back into territories more and more confined. Its meadow species of hygro-meso-philous character often take refuge growing, depending upon the habitat conditions, into different zones of the fill slope. The evaluation of their ecological conditions has already been discussed (Bodrogközy, 1966). On the other hand, there may be raised also the question, of what practical value are the grass associations, developed on these dams in different expositions and natural heights that originally, in the period of dam building consisted of artificially produced grass combinations. It is a fact ascertained that these, over a period of decades, have sufferred major changes, not in the last resort a differenciation, so that they cannot fulfil their duty any more in a degree expected of them. The main problem is their being thinned out during the years, the sown species being succeeded, pressed back by other species complying more with the habitat conditions, so that they are falling short of being suitably closed and of forming a root tissue in the layers of soil just below the surface — that had to eliminate or at least decrease the substance of dams demaged, by foaming the high flood.

An aid for the solution of these questions, given in biological respect, can anyhow be considered to be reassuringly established only if it is founded on data of adequate experiments and observations for a longer time.

The not suitable closing and dominance values as well the insufficiency of the root tissues of the grass associations can be attributed to several causes.

1. One of them is the not satisfying supply with nutritive material owing to which the individuals developed more weakly were falling victims to the species more developed an resistant, resp. to their single organisms. This supposition is obvious if we realize that, in the past, the nutrient supply of these dams has not taken place. In this way, first of all on slopes of southern exposition, the perished root amount of the flora has become fast oxidized, and these disturbances in the nutrient supply of the dam grass have caused a considerable decrease of their closing and products.

2. The absence of a satisfying water supply may also influence negatively the state of dam grass. That is demonstrated by the significant differences between the periods of vegetations rich or poor in the annual precipitation. In this case, namely, even an optimal nutrient supply cannot be properly effective. As we could not deal with the latter problem, as regards the merits, in default of satisfying irrigation experiments started, we have chosen first of all the administration of the different doses of different fertilizers in different aspects, resp. their effect on the different phytocenoses of the dam grass, to be topics of our investigations.

At any rate, our theoretical results to be expected may promote the practical purposes of our specialists in water conservancy, as well. Thus, with participation of the Institute for Agricultural Research in the South-Hungarian Plain, and organized by the Management of Water Administration in the region of the Southern Tisza, dam-grass reconstruction experiments have started in three places along the Tisza in 1965. We have had two aims: to evaluate, and later on to use, the influence exerted by the fertilizer doses administered in different times and amounts upon the single dam-grass cenoses, then, through that, also the degree of the biological dam stabilization and, finally, the qualitative and quantitative changes in production of the different kinds of dam grass like grass-lands, at different expositions.

The series of experiments were planend and supervised by a scientific research worker of the Institute for Agricultural Experiments. Dénes Gratzl, with regard to the corresponding phytocenological points of view.

Method

North of Szeged, in the region of Tápé-Vesszős, on the dam of the right bank of Tisza, on its full breadth, from the external dam basement to the internal one, we have set 10 m lots with lines of 24 kinds of treatment (+ one control) in four repetitions.

The experimental results, — that is to say, the questions, what qualitative and quantitative changes were caused by the application and administration of solo, double, resp. triple combinations of superphosphate, potassium salt (of 40 p.c.), as well of ammoniumnitrate in the different dam-grass aspects, on the single lots of dam grass, — were evaluated, resp. appreciated in three ways.

1. Cutting overground products in a fully developed state (period of flower-

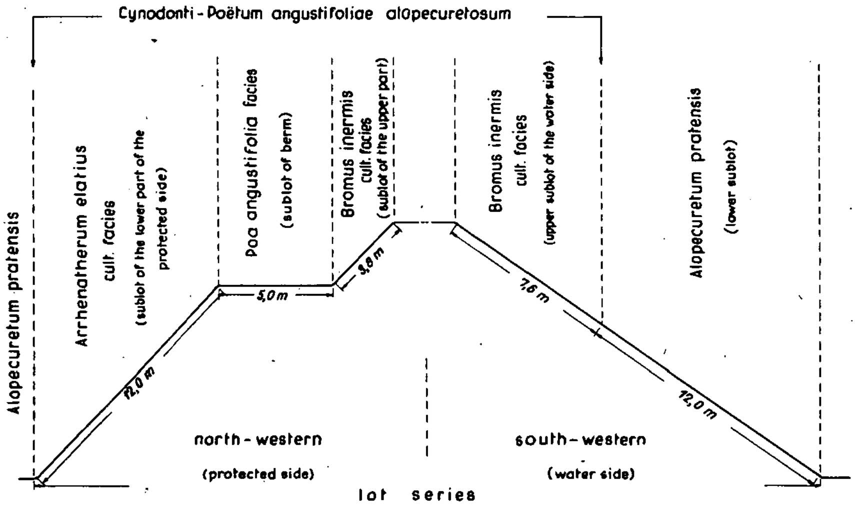

Fig. 1. Sublot system of the experimental lots of the dam-grass association *Cynodonti-Poëtum angustifoliae alopecuretosum*, following the zonation.

ing), weighing the amount in air-dried state. We have got informations first of all about the changes concerning the total species, both on the defended and the inundation, sides, separately.

2. About the qualitative changes that are influenced by the quantitative change of the species components of the given experimental lots in the same way as the disappearence or immigration of the single species, we have obtained informations by the help of adequate phytocenological methods, owing to their individual adaptability, reacting differently to the influences of nutrient doses. With their help, the changes of the single phytocenoses can be evaluated, analysed until species.

3. Newly, we have succeeded in getting — on area units, known on the basis of the height, dominance conditions of the occurring species, — to production values that are in a close connection with the weights of the air-dry plant product.

Our work has been rendered highly difficult by the fact that, in consequence of the water supply and the differences between expositions, in the single lots and inside them, zones of different associations are running through. An explanation for that may be that the grass cover, developed by the original homogeneous sowing, gradually changed as a result of the differences in exposition, natural features of land and hydrography, and owing to the struggle with species that occur in a wild state corresponding with the ecologic conditions of the area, and it developed so the species composition of the single associations. It can be explained in this way that there are dam sections where but a few traces of the original grass plantation may be noticed; in different conditions, however, some planted species may have a dominating role even after eighty years, contributing more or less to realize the formation of a defending and profitable grass culture of dams. We have divided, therefore, the lots of an anyway wide estent into three sections on the defended side (lower slope, berm, upper slope), and into two ones on the water side of dams (inundated lower and defended upper sections). The detailed results are summed up according to lots (Fig. 1).

A survei of dam-grass associations of the experimental lots

In our area, as influenced by the different biotical and abiotical factors, our dam grasses are showing the following zonal arrangement.

1. As a result of a northern exposition, the insolation has decreased. A cooler phytoclimate has been brought about by the increased shade effect (Bodrogközy-Horváth-Tassy, 1967). The grass species sown originally keep having a dominant role today, as well.

1.1. The vegetation of the lowest zone below the dam basement is characterized by an increased hydrographic effect. Below the protected dam slope of northern exposition, partly the dam basement becoming drenched, partly the drenching effect of stagnant waters coming from floods of inundation waves may conduce to a zone of similar basic structure.

1.2. The microclimate of the lower part of dam slope is favourable to some species, as well, that are more sensitive to the continental influence. These are common first of all in the grass-lands of Transdanubia, i.e. the part of Hungary that lies between the Danube, the Drava and the western frontier of the country, resp. in the mesohygrophilous meadows of the Great Hungarian Plain. Thus *Arrhenatherum elatius, Festuca pratensis, F. rubra,* etc. The first of them has maintained its dominant role; its closing, however, is not satisfying. Its substances, with its species components together, are showing a total cover of 40—60 percent.

1.3. In the grass cover developed on the lower lot of the middle dam berm. *Poa angustifolia* from time to time gains ground, and the typical species of *Cynodonti-Poëtum angustifoliae* and at some other time — particularly in weedy spots — some of its other species, too, may form new facies. The appearance of the highly dominant *Poa angustifolia* is very positive for our purposes, first of all from the point of view of making the dams solid. This is namely a species forming a closed grass cover on the surface, and a dense root tissue in the soil layer near to the surface of dam, apparently excellent for tasks of protection.

1.4. In the zone of dam slope near to the crown, the favourable living conditions produced by the northern exposition decrease. The main cause of that is that the soil layers in that level do dry up faster. Therefore, the grown grass species that demand more care are succeeded, resp. pressed back by other species being more adapt to the xerothermic essential conditions: *Bromus inermis, Dactylis glomerata.*

In the composition of the grass of that zone, there isn't any considerable difference in the relation of waterside and protected slopes.

2.1. In the upper sublots of the south-eastern dam slopes, the insolation, as a consequence of exposition, is reflected in a higher degree in the soil, warming and drying up more intensively. From the grass species sown, the more sensitive ones were mostly missing in our experimental lots, as well (representatives of *Arrhenatherum elatius, Festuca pratensis,* and *Papilionaceae).*

2.2 From the settled grass species, only *Bromus inermis* had a role in a rather considerable cover. The species exchange lasting for a series of decades is, therefore, here the most intensive. In the place of the extinct species there developed gradually the facies of *Cynodonti-Poëtum angustifoliae.* Not one of these facies can be formed by *Salvia nemorosa, Glycyrrhiza echinata* considered as weeds from the point of view of practice. The effect of biological defence of dam grasses and the quality of hay obtained from there are namely damaged by these.

In the zone of the dam crown, there occurs a complex of *Cynodon-Lepidium draba,* mainly at a purely southern or southwestern exposition producing the driest ecological conditions; it occurs, however, but rarely in our lots, touching but a narrow zone of the crown edge in a few meters breadth.

2.2. In the sublot of the lower part of the south-eastern dam slope, as a result of the constant floods, there developed different facies of *Alopecuretum pratensis: Aristolochia clematitis, Thalictrum lucidum Viola ambigua, Equisetum arvense.*

3. In the slope parts where in the Past a storage of dam-protecting objects (stake piles of brushwood) took place, owing to their mouldering and decay an accumulation of organic matter occurs. Its effect presents itself even after some years, influencing the grass homogeneity of the assocaitions in the lots of dam grass in our experiments in an unfavourable direction. The nitrophilous species, like *Erodium cicutarium, Lepidium draba, Galium mollugo, Taraxacum officinale, Polygonum aviculare* and, last but not least, *Convolvulus arvensis,* can namely influence the real evaluation of the single lots with their considerable expansion in a negative direction.

Influence of nutrient doses on grass cenoses of the experimental lots

From the four repetitions of the experimental lot system delimited in the area of Vesszős, a detailed cenological evaluation of series 3 took place, both on its protected and inundation sides, in the second vegetation period after the treatments having started.

The influence of the administration of fertilizers upon the grass association can be summed up as follows:

1. Evaluation of the north-western protected side of dam in the spring aspect, in the relation of three sublots in every lot.

1.1. Control lot:

On its lower slope part (lst sublot) *Arrhenaterum elatius* is dominant in the species association of the dam grass. Its closing is anyway obtaining a half part of the total cover; thus *Poa angustifolia*

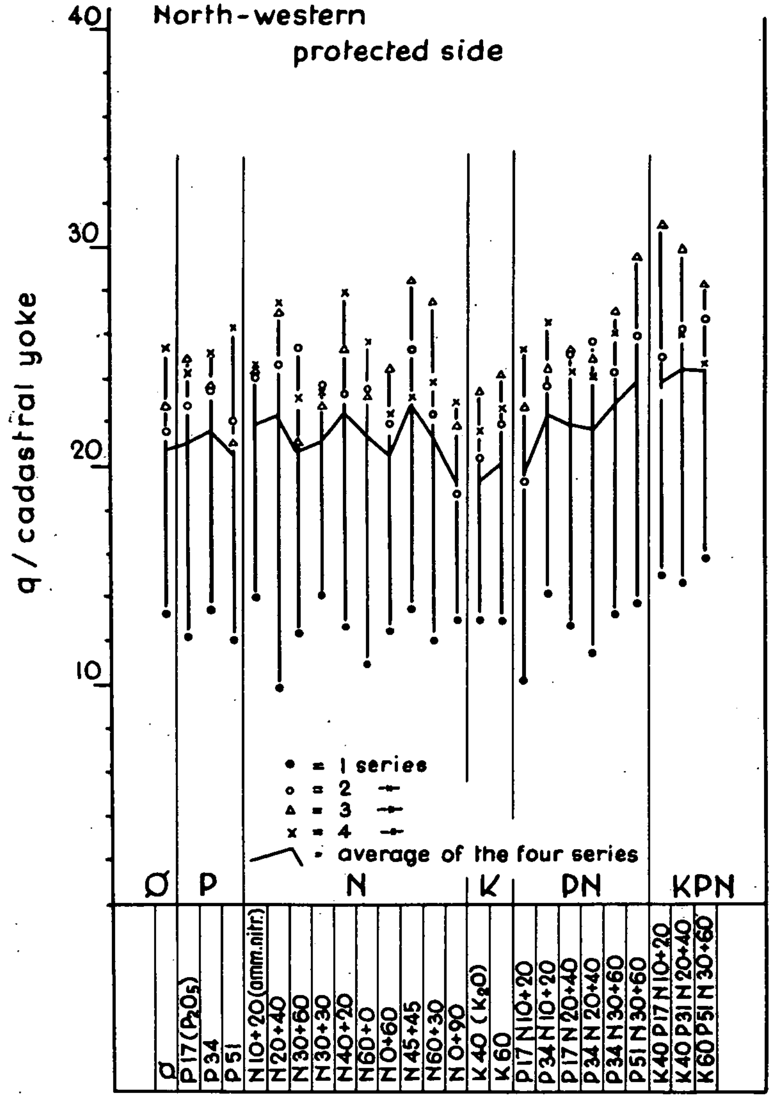

Fig. 2. A quantitative division of the overground airdry product of the experimental lot series of dam with nort-western exposition, in the spring aspect (May 27, 1967). After fertilizer abbreviations (ammon-nitrate: N, potasium-salt: K, s uperforsphate: N), no. 1 is indicating the fertilizer amounts of early spring, no. 2 those administered in autumn, both at solo and at combined treatments. 1—4: are repetitions of the lot series.

could achieve a dominance value of about six, *Galium mollugo* about ten percent.

On the berm part of dam side, the two previous grass species change their places, and *Poa angustifolia* is represented with 20 p.c.

So the previous culture facies *Cynodonti-Poëtum angustifoliae Arrhenatherum* is substituted by the facies *Poa angustifolia.*

On its upper slope part, as a result of the dry ecological-phytoclimatic conditions, the sown *Bromus inermis* prevails, sharing proportionately the *Gramineae* 40 p.c. total cover with *Arrhenatherum* and *Poa angustifolia.* A value over five percent is obtained by *Convolvulus arvensis, Plantago lanceolata* and *Salvia nemorosa.*

1.2. Phosphorus treatment:

Compared with data of the control lot, there was no major difference to be found. We are analysing the differences not in the value of dominance but in the production of overground green amount, applying the method used by us for a long time (Bodrogközy-Harmati, 1966) taking for a basis, anyhow, the 1 p.c. cover per species. (So we obtain a rather real picture as the distribution of species per lots is uneven and the influence of fertilizers is not always reflected in the weight value). In that way it can be demostrated that e.g. *Arrhenatherum elatius* has shown a downward tendency in all the three sublots as compared with the control in point of the value of production. Also the total cover of species was lower. As to the dose difference of superphosphate: applied in autumn, there wasn't any major difference between lb. 68 per 244 sq. m and lb. 102 per 244 sq. m, either, as regards the single species or their products. (Tabl. 1).

1.3. Treatments with ammoniumnitrate.

Evaluating them we have got unexpected results. As a rule, it is more or less of positive influence concerning the production of grass associations getting fertilizers of nitrogen content. On our lots, anyway, we couldn't observe any major differences even in case of the administration of higher doses, as compared with the lots untreated. It is to be supposed that the amount of the 150 mm precipitation in months March, April and May of 1967 assured a satisfying and even ancreased nutrient intake in the control lots, as well. In the drier periods of the former year, namely, the hydrolysis of humus substances, produced and accumulated by the decay of roots, and their utilization by the grass cenoses were slower, owing to the climatic effects of the northern exposition. In the spring aspect, rich in precipitation, of the following year of investigation, therefore, the influence of the applied N-fertilizer doses was not of considerable importance in that dam part.

2. In the summer aspect of the protected, north-western slope of the dam, *Arrhenatherum* has further on kept its dominant role. Its maximal productivity could be observed in the lots that have solo obtained ammoniumnitrate in the way that one-third of the dose was spread in autumn and two-thirds of it in spring. Such a high value was not produced in case of applying combined fertilizers, either. (The calculation is referring here, too, to 1 p.c./100 sq.m).

An opposite effect, as compared to the control, was observed as a high phosphorus dose had been applied; then the production of *Arrhenatherum* showed a significant decline (Tabl. 2).

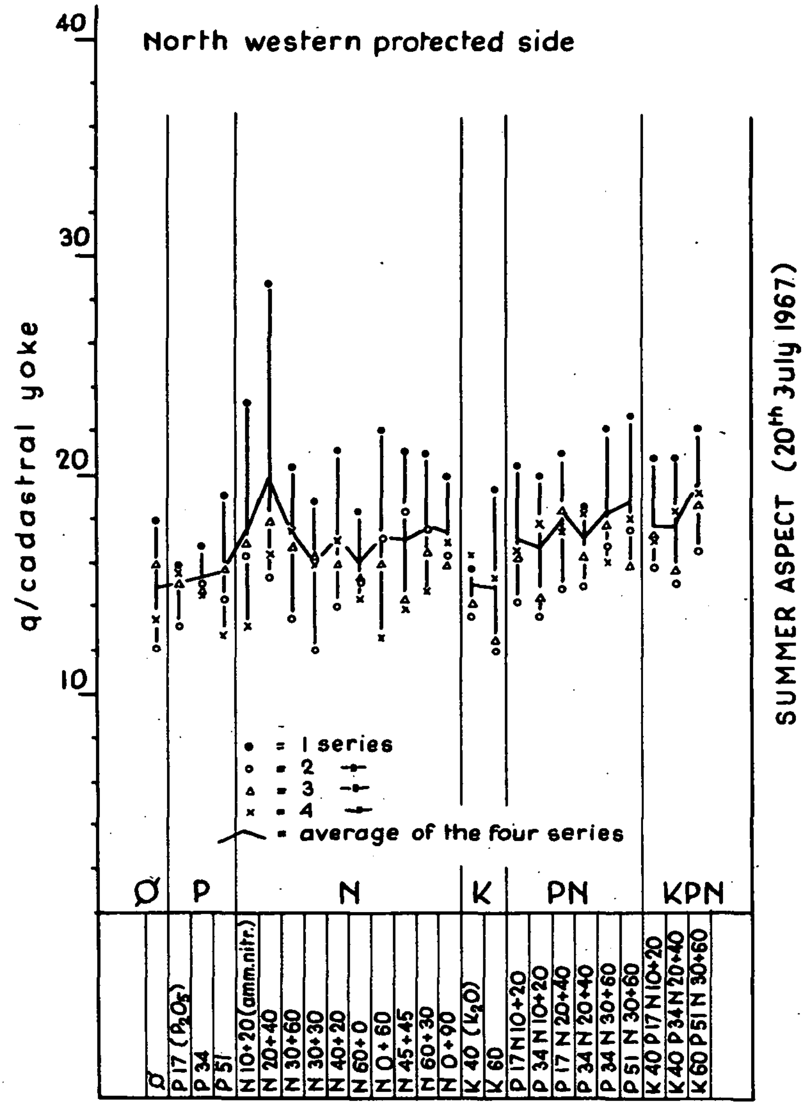

Fig. 3. Air-dry products from the summer aspect of the experimental lot series of north-western exposition (July 20) (a detailed explanation can be found in Fig. 2).

3. In the spring aspect of the south-eastern dam slope, on the inundation side, in 1967, owing to the prolonged highwater of floods, the lots are sharply separated into a lower sublot covered by *Alopecuretum pratensis* and containing several hygrophilous species and into the sublot containing the culture facies of the dam slope above the flood line of *Cynodonti-Poëtum angustifoliae Bromus inermis,* dominated by

Tabl. 1

Fertilizer dose (kg). (The first figure following the shortened sing of the mineral fertilizer is indicataing the amount administered in the spring period, the second figure that afforded in the autumn period. Size of lot 244 sq. m)	Ø			P 51+0			N 30+60			K 40 P 34 N 30+30			K 60 P 34 N 30+60		
Distribution of sub-lots of the single test lots	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper
	sublot			sublot			sublot			sublot			sublot		
Number of the single sub-lots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Agrostion-, Arrhenatherion-, Molinio-Arrhenatheretea species:															
Dactylis glomerata	2	1	1	1	1	2	2	1	1	3	1	2	2	4	2
Arrhenatherum elatius	25	15	3	5	3	2	1	2		60	20	15	35	8	4
Alopecurus pratensis	5	4	10	4	5	15	28	5	10		5	10	6	10	20
Ranunculus acer	3	4	3	2	3	2	0,5	1	0,5	1		2	1	2	1
Galium mollugo	13	12	5	8	6	4	16	20	8	1			0,5	3	5
Lotus corniculatus	2			0,5						1	0,5		1		
Pastinaca sativa ssp. *pratensis*										1		1		1	
Scutellaria galericulata				0,5	0,5										
Bromion-, Festucetalia-, Festuco-Brometea species:															
Bromus inermis	3	2	30	16	14	8	3	16	38	8	5	30	8	25	30
Poa angustifolia	8	4	5	10	8	5	12	10	12	8	10	5	10	5	
Carex praecox	3	10	8	10	20	10	3	13	3	0,5		5		3	5
Salvia nemorosa		3		1	3	2	0,5	3	1		10	5	1	6	3
Myosotis micrantha	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5					0,5	0,5	
Plantago lanceolata	1	3	1	1											
Achillea collina		1		0,5		0,5							1	0,5	1
Calystegion-, Secalietea-, Onopordetea species:															
Lepidium draba	1	6	8		3	3	1	1	2		10	6	0,5	5	3
Convolvulus arvensis	2	3	2	2	3	1	3	2	2			2	1	2	2
Valerianella locusta		1	1	1	1	1		1					0,5	0,5	
Melandrium album	0,5	0,5			1		1	1				0,5	0,5	1	
Lathyrus tuberosus												0,5	4	1	1
Stenactis annua	0,5	0,5	0,5												
Polygonum amphibium	0,5	1					0,5								
Calepina irregularis					0,5	0,5									
Lamium purpureum					0,5										

Table. 2. Percentage of dominance values obtained from the upper sub-lot of the test-lots of the south-eastern dam slope (lot size being 63.3 sq.m).

Fertilizer dose (kg): (Size of sub-lot: 150 sq. m)	Ø	P 51+0	N 30+60	K 40+0	K 40 P 34 N 20+40	K 60 P 34 N 30+60
Number of the single sub-lose:	1	2	3	4	5	6
Bromion-, Festucetalia-, Festuco-Brometea species:						
Bromus inermis	15	15	60	30	40	45
Carex praecox	20	20	5	20	10	8
Poa angustifolia	5	18	2	8	2	6
Salvia nemorosa	2	5	2	3	2	5
Myosotis micrantha	1	0,5		0,5		1
Coronilla varia	0,5	0,5		0,5		
Achillea collina					0,5	0,5
Poa bulbosa	1					
Agrostion-, Molinio-Arrhenathretea species:						
Alopecurus pratensis	2	2	3	3	3	5
Dactylis glomerata	1	1	2		1	2
Galium mollugo		1	0,5			
Pastinaca staiva var. *pratensis*						0,5
Secalietea-, Onopordetea species:						
Melandrium album	1	0,5	2	1	2	1
Convolvulus arvensis	3	2	1		5	5
Valerianella locusta	2	1		1	1	1
Lepidium draba	3	1		2	2	
Vicia tetrasperma	2	0,5		1	1	
Lathyrus tuberosus				1		1
Veronica arvensis					1	0,5
Stenactis annua			0,5	0,5		
Euphorbia virgata				0,5		
Sedum acre				0,5		
Lamium purpureum	0,5					

xerophilous species. Because of being long covered by water, the sublot of the lower zone could not be evaluated.

The influence of the different doses of different fertilizers can be summed up as follows:

3.1. In the control lot, 70 p.c. of the total production of grass species was produced by the sown *Bromus inermis,* while the *Poa angustifolia* amounted but to a fourth part of the former one. *Carex praecox, Convolvulus arvensis, Salvia nemorosa,* etc. have a considerable dominance value.

3.2. The effect of potassium and phosphorus, opposite to the control, caused but insignificant phytocenological differences.

3.3 The influence of the n i t r o g e n treatment was considerably greater opposed to the lot of northern exposition. The reason of that may have been that the oxidation of humus materials produced in the course of the decay of roots is of faster rhythm, as a consequence of a more extensive insolation owing to the south-eastern exposition, and, therefore. the grass associations of the slope parts of south-eastern exposition may have habitats poorer in nutrients than those of northern exposition.

In the species association of the lot the most intensive advance was shown by *Bromus inermis*. From 15 p.c. D-value of the control, as influenced by higher nitrogen fertilizer doses, it rose to a value of more than 60 p.c. As a consequence of its increased competitiveness, the number of species of the cenoses of the experimental lot decreased 50 p.c. Further data can be found in Table No. 3.

4. In the summer aspect of the south-eastern dam slope the following changes could be observed.

4.1. Under the c o n t r o l conditions, it can mainly be attributed to the increased insolation and destitution in nutrients that the dominance values of *Bromus inermis* were repressed to one-third opposite to the *Cynodon dactylon* breaking forth and growing dominant. In order of sequence there follow *Convolvulus arvensis, Poa angustifolia* and *Salvia nemorosa.*

4.2. In case of some species, particularly in that of *Poa angustifolia,* the influence of p h o s p h o r u s is obvious at south-eastern exposition, both if lower and if higher doses were administered. As a result of suerphosphate of lb. 102 administered in autumn, as compared with the control, a fourfold increase of dominance percentage could be demonstrated. This proportion was however not shown by the height values so, as regards production values, the increase has not shown such a steep tendency.

4.3. I n f l u e n c e o f n i t r o g e n d o s e s.

The most obvious is the behaviour of *Cynodon dactylon* as compared with the increasing N-doses. While the closing of *Bromus inermis* increases ni direct proportion to the increase of ammoniumnitrate doses, *Cynodon* couldn't produce a major dominance value in any lot treated with nitrogen, approaching that of a control lot.

As to the species number and to the significant species, it could be established that the low species number of the south-eastern exposition was to be followed in every lot. Therein also the high D-values of Bromus inermis may have played a great part besides the extreme micro-climatic conditions.

4.4. In case of the doses administered alone, there could not be demonstrated any p o t a s s i u m effect, either from the point of view of cenosis changes of from that of productivity (Fig. 3). The reactions of some combinated treatments are given in Table 4.

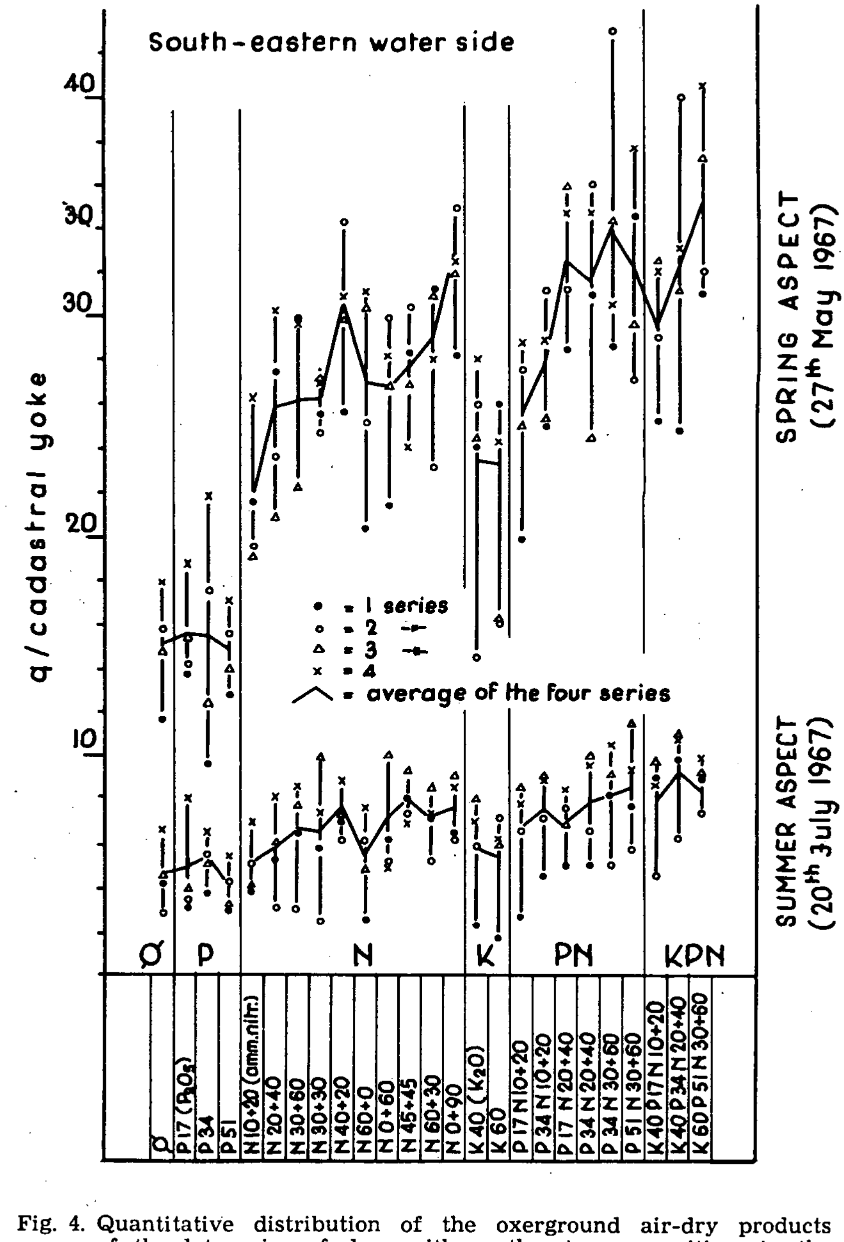

Fig. 4. Quantitative distribution of the oxerground air-dry products of the lot series of dam with southeastern exposition, in the spring and summer ospects. (A further detailed explanation can be found in Fig. 2).

Influence of fertilizer doses on the rhythm of life in the experimental lots of dam grass

In the course of elaborating the data of control lots, it could be ascertained that they could provide but a rather weak biological protection against the flood waves in early spring and against the scumming activity of the dam-grass cover in case of high water. On the lots getting a nitrogen or a combined fertilizer treatment,however, acording to our phenological observations, the development of the vegetation in early spring precedes and overshadows the lots intreated or treated by solo phosphorus alone. The grass cover closing that is accelerated as a result of nitrogen is affording, therefore, an increased biological defence against the early spring flood waves.

Investigation of the resistance of the experimental lots of dam grass and of their soil

For deciding the question in what degree the defensive biological tasks required from the species associations on the different experimental tables in different dam zones in case of unlike fertilizer doses are served, we have to investigate the organic matter values of the soil determined on soil-physical basis (these investigations have been performed by Dr. András Fekete).

On the basis of these values of organic material content some consequences may be drawn concerning the harmony of the solidity of soils and their being woven through by roots produced mainly by the dominant grass species, resp. concerning to the ratios of the resistance of the different soil sorts. Anyway, we cannot get any absolute values because of the limits of precision of these methods. The connections between the data obtained and the plant species in question may be summed up as follows.

1. The values of resistance, and those of being root-grown by the dam-plant cover, are depending first of all upon its zonation conditions, and only in the second place upon the single species, resp. the administration of fertilizers.

2.1. The best values are coming from the plant associations of the experimental lots of the lower slope part of northern exposition where, in our area, the culture facies of *Cynodonti-Poëtum angustifoliae Arrhenatherum* is to be found.

2.2. Similarly, we have got good values in the substances of *Alopecuretum pratensis* at the water side. From all these it may be observed that the most luxurient vegetation roots develop in the dam zones of wet and cool habitat; theretore, it is here, as well, where the humus accumulation and, as a consequence of it, the resistance of the dam section are the most favourable.

2.3. A middle-sized resistance is belonging to the dam-berm zone, covered by *Cynodonti-Poëtum angustifoliae typicum* (resp. its facies

Tabl. 3

Fertilizer dose (kg): (Size of lot 244 sq. m)	Ø			P 34+0			P 51+0			N 10+20			N 30+60			N 40+20			N 0+60			N 45+45			N 0+90			K 40 P 17 N 10+20			K 60 P 34 N 30+60			K 40 P 34 N 20+40		
Distribution of sub-lots of the single test lots:	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper	lower	berm	upper
	sublot			sublot			sublot			sublot			sublot			sublot			sublot			sublot			sublot			sublot			sublot			sublot		
Number of the single sub-lose:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Bromion-, Festucetalia-, Festuco-Brometea species:																																				
Poa angustifolia	6	20	15	3	12	15	4	20	20	3	12	18	2	4	8	2	22	12		20	14		8	20	4	8	15	14	22	20	20	18	18	20	16	15
Salvia nemorosa	0,5	20	1	0,5	8	6	3	8	0,5	1	0,5	4	4	8	6	4	8	2	1	9	2	2	3		7	3	2	3		20	3	1	2	4	10	6
Bromus inermis		6	10	0,5	4	8		4	12			10	3	30	18		4	8	1	5	2	1	1	6	18	5	10	4	5	4	2	4	5	2	12	5
Plantago lanceolata	2	3	6	8	4	2	4	2	4	0,5	0,5	1		0,5	0,5	2	0,5	0,5		0,5	3			1			0,5	1	1				0,5			
Achillea collina		1							0,5											0,5	0,5						0,5									0,5
Carex praecox											4	0,5					4																			
Agrostion-, Arrhenatherion-, Molinio-Arrhenatheretea species:																																				
Arrhenatherum elatius	30	5	15	25	5	3	18	4		15	0,5		15	2	12	5	3	2	38	6	8	50	25	8	20	18	4	25	15	15	30	25	15	30	10	15
Galium mollugo	10	15	8	15	25	20	8	15	5	15	6	12	8	7	6	12	22	3	0,5		1			6				0,5	0,5		2	4	1			3
Ranunculus acer	1	2	2	1		2	1	0,5		0,5	0,5	1	0,5	0,5						0,5								0,5	0,5		0,5	0,5	0,5	0,5		
Alopecurus pratensis			2		1	0,5		1	1			0,5	2	1	1	30		3			3					5	3					0,5	2		2	2
Lotus corniculatus		1	2	0,5	1	1	1	2	4						0,5				0,5									5	0,5	0,5	0,5			0,5	0,5	
Vicia cracca	2	1	3	1		5	3					5	1	0,5				0,5										0,5						1		
Pastinaca sativa ssp *pratensis*		1						1	0,5	1			2	0,5		1															1			1	1	1
Dactylis glomerata																			0,5	0,5	1			0,5	1	1	1									
Potentilla reptans	2																											0,5								
Chrysanthemum leucanthemum			3																																	
Festuca pratensis																									1											
Calystegion-, Onopordetalia-, Secalietea-Chenopodietea species:																																				
Convolvulus arvensis	3	6	10	1	10	10	6	20	5	4	3	8	3	5	5	0,5	5	4	0,5	4	3	2	1		0,5	5	4	2	14	8	1,5	6	6	3	4	5
Melandrium album	1		1				0,5		0,5	2	2	1	1	2	0,5	2	1	0,5	0,5		1			0,5	0,5		1	0,5	3			0,5		0,5		
Lepidium draba			3			4		0,5		0,5	10	2			1			0,5		0,5	1		0,5	0,5											0,5	
Lathyrus tuberosus	0,5	0,5	1	1					0,5				0,5					3		3	15									0,5			0,5	1		1
Verbena officinalis		0,5		0,5			0,5				0,5	0,5					0,5	1					0,5		0,5	0,5	0,5									0,5
Cichorium intybus							0,5		1	0,5		1			2	0,5				0,5	1								0,5				2			0,5
Glycyrrhiza echinata					0,5	0,5		0,5			1				0,5				0,5	0,5	0,5						0,5									
Setaria viridis					2			2			1,5		0,5	0,5	0,5	2		1									0,5									
Equisetum arvense				1			2			4			2												1			1			0,5			1		
Erigeron canadense	1	1			1			1			1						0,5			0,7			0,5													
Ballota nigra																0,5	2			3		0,5	1	4						0,5		1				
Polygonum amphibium f. *terrestre*	1	1											4			1									1	2	3									
Polygonum aviculare									5			5			9									4			3			2			2			
Agropyron repens										10			8				1														1				3	2
Medicago sativa													1	2																						

Table 4. Distribution of the covering values obtained from the upper sub-lot of the lots of the south-eastern dam slope, in the summer aspect.

Fertilizer dose (kg): (Size of sub-lot: 150 sq. m)	Ø	P 34+0	P 51+0	N 10+20	N 30+60	N 40+20	N 0+60	N 45+45	N 0+90	K 40 P 17 N 10+20	K 40 P 34 N 20+40	K 60 P 34 N 30+60
Number of the single sub-lose:	1	2	3	4	5	6	7	8	9	10	11	12
Bromion-, Festucetalia-, Festuco-Brometea species:												
Bromus inermis	5	8	5	30	40	24	40	60	50	50	47	46
Poa angustifolia	8	20	30	18	3	20	8	12	6	14	5	8
Salvia nemorosa	6	1	7	4	3	8	12	6	8	7	6	6
Carex praecox	6	3	4	5								
Plantago lanceolata			2	0,5		0,5	0,5					0,5
Agrostion-, Arrhenatherion-, Molinio-Juncetea species:												
Galium mollugo		5	5	3								
Dactylis glomerata									0,5	1	2	
Arrhenatherum elatius			1			2					2	
Lotus corniculatus		0,5	4									1
Alopecurus pratensis				1								2
Pastinaca sativa var. *pratensis*												0,5
Calystegion-, Onopordetalia-, Secalietea-, Chenopodietea species:												
Convolvulus arvensis	20	15	8	6	1	1	6	12	5	10	8	5
Glycyrrhiza echinata	3	0,5	4	1	2	2	0,5	0,5	2	10	0,5	3
Melandrium album	3	1	3	0,5	4	3	1,5	1	0,5			
Cynodon dactylon	30	8	8	4	8	3			6		5	
Verbena officinalis	1	0,5	3	0,5		1		0,5		0,5	0,5	
Setaria viridis	3		3	3		4						
Lathyrus tuberosus	1		0,5							1		1
Cichorium intybus			0,5	2	0,5		1					
Polygonum aviculare			3	3		2						
Polygonum amphibium f. *terrestre*										2	0,5	1
Crepis sp.				0,5	2	0,5						
Agropyron repens				4								
Erigeron canadense		0,5										
Equisetum arvense												0,5

Arrhenatherum), where the amount of soil moisture and the root amount of flora already strongly decreases.

2.5. The weakest resistance was shown with help of this method by the upper zone of the dam slopes of southern — south-eastern exposition. This zone is, in the same time, the most intensively warmed one (B o d r o g k ö z y - H o r v á t h - T a s s y, 1967) in which the humus content is fast oxidized and the lower soil-moisture values make possible only the development of a little root amount.

2.6. After the first two years, it would be too early, as yet, to measure the influence of the different fertilizer doses on the increase of resistance. It seems so anyway, on the basis of the results so far, that a combined administration of the phosphorus, resp. potassium-phosphorus-nitrogen fertilizers is still not favourable enough to increase the resistance, even after an experiment of two years.

2.7. In conection with all these, however, it is to be noted that the biological protection of dams can be influenced in a positive direction, apart from the resistance of soil, by the overground green amount of the grass associations, as well. This increased productivity, — as established above — can be achieved both in time and in amount with the fertilizer doses applied by us, and, in case of high water, the scumming activity of the flooding waves on dams can be diminished or even eliminated.

Summary

Author has dealt for several years with studying grass associations of the Tisza dams. His establishments, — apart from the theoretical problems of the succession of grass cenoses summing up the changes realized so far concerning the species combinations developed on the dam slopes by setting, — may serve as basis also for solving practical problems.

It is a well-known fact both from a theoretical and a practical point of view that the closing of dam vegetation, first of all under unfavourable conditions in the upper dam zone of southern exposition, is leaving much to be desired. This problem arises in an increased degree, nowadays, as the problems of the biological defence and of grass output of dams are getting more and more into the centre of interest of the practical specialists. For solving that questoin, north of Szeged between the communities Algyő and Tápé) at the right bank of Tisza, on the whole breadth of the dam slope, series of experiments for administering fertilizers were organized in 1966. Solo and combined doses of nitrogen, phosphorus, and potassium amounts were administered in different dates. Their effect can be summed up as follows (on the basis of the dates of their phytocenological analysis in 1967):

1. Changes of the overground grass product:

1.1. Evaluation of the dam-slope lots of north-western exposition according to sublots (the sublots are separated according to the zonal division of the dam).

1.1.1. Neither in the lower, berm, nor in the upper slope zone, as compared with the control lot, even the nitrogen (ammoniumnitrate) fertilizer had, in this year, any considerable product surplus.

This is, first of all, a consequence of a favourable distribution of precipitation.

1.2. The south-eastern side — at the inundation area — showed a considerable difference, first of all in case of the sublots placed in the upper dam level.

1.2.1. Potassium had but a minimal influence, somewhat it was more favourable to apply phosphorus, and the most intensive was the effect of the usage of nitrogen, concerning the percentage of products, resp. that of dominance, in solo and combinated forms. In the whole lot series, the *Bromus inermis,* sown before several decades, has had a leading position. Its dominance, as a result of N-doses, has quadrupled in the spring aspect, as compared with the control. On the other hand, in the summer aspect, under control conditions, *Bromus inermis* was pressed back to one-third of its amount by the prevailing *Cynodon dactylon.*

1.2.2. The effect of phosphorus, at south-eastern exposition was of favourable influence on *Poa angustifolia.*

2. The degree of an increase of resistance of the experimental lots on the dam grass against inundation is determined, as a rule, by using the values of the organic material content of soil established on soil-physical basis. During the second experimental year it could be ascertained that:

2.1. The resistance values of the grass cover of dam slopes and their being grown by roots are depending first of all on the zonation conditions, and only in the second place on the single species and the administration of fertilizers. The resistance order of the single dam zones is as follows:

I. *Cyrodonti-Poëtum angustifoliae alopecuretosum,* culture facies *Arrhenatherum elatius* (north-western exposition, lower slope part).

II. Lower slope part, at the water side, of the different facies of *Alopecuretum pratensis.*

III. *Cynodonti-Poëtum angustifoliae typicum,* in the dam-bern zone.

IV. *Cynodonti-Poëtum angustifoliae Bromus inermis,* in the south-eastern upper zone.

2.1.2. The influence of the different fertilizer doses concerning the resistance of the dam slopes against the inundation could not be ascertained, as yet, during the second year of investigations.

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