THE EFFECT OF DIFFERENT FORMS OF POTASH FERTILIZERS ON YIELD AND COMPOSITION OF ALFALFA AND COCKSFOOT IN PURE STAND AND MIXTURE

II. CHEMICAL COMPOSITION AND PALATABILITY

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Abstract
The effect of different forms of potash fertilizers on the chemical composition and palatability of alfalfa, cocksfoot and mixture between them was studied during 2006 – 2008 in the Institute of Forage Crops, Pleven, Bulgaria. Alfalfa (Medicago sativa L.) variety *Pleven 6*, cocksfoot (Dactylis glomerata L.) variety *Dabrava*, and mixture between them were tested. The following potash fertilizers were used: MOP- (60% K_2O); Korn-Kali (40% K_2O, 6% MgO, 3% Na, 4% S), and Magnesia-Kainit (11% K_2O, 5% MgO, 20% Na, 4% S). We did not observe differences of crude protein and crude fiber contents after the potash fertilizing. Crude protein was higher and crude fiber lower in fourth cut, which was formed in autumn months. In cocksfoot and mixture, crude protein increased from first to fourth cut, but crude fiber decreased, because cocksfoot formed generative stems at first cut and leaves only in next cuts. There was a tendency to decrease of potash content from first to fourth cut. The concentration of potash was lower in alfalfa and higher in pure cocksfoot. A regression equation was worked out, which demonstrated a negative correlation between potash content and calcium (r= 0,745), and between potash and crude protein. Potash fertilizers decreased calcium content. Calcium was higher in alfalfa, decreased in mixture, and was the lowest in cocksfoot. Potash fertilizers had no effect on phosphorus content in alfalfa and cocksfoot. There were no differences in the forage palatability in variants depending on the form of potash fertilizer, but there was a tendency to increased palatability in fertilized alfalfa, cocksfoot and mixture compared to unfertilized variants.

Introduction
The production and quality of forage crops and grasses depend on many factors including mineral fertilizing. The application of mineral elements aims at creating optimal conditions for realization of the genetic potentialities for obtaining of higher yield from the forage plants and higher forage quality (Meyer, 2006). The higher nutrient and mineral content in forages allows easy balancing of the rations depending on animal requirements and improvement of their nutrition. In Bulgaria, alfalfa is the main forage for hay and haylage, and its agronomic and zootechnical quality is often an object of study.
The aim of this study was to investigate the effect of different forms of potash fertilizers on the contents of crude protein, crude fiber, *Ca, P, K*, and palatability of alfalfa, cocksfoot and mixture between them.

Materials and methods
A field trial was carried out in the Institute of Forage Crops, Pleven with alfalfa (*Medicago sativa* L.) *variety Pleven 6*, cocksfoot (*Dactylis glomerata* L.) variety Dabrava and mixture between them in ratio 1:1. Different forms of potash fertilizers were applied: Muriate of Potash (MOP)- 60% K_2O; Korn-Kali (40% K_2O, 6% MgO, 3% Na, 4% S), and Magnesia- Kainit (11% K_2O, 5% MgO, 20% Na, 4% S). The nitrogen fertilizer was applied as ammonium nitrate

and the phosphorus one as triple super phosphate. The scheme of treatments was described in the first paper (Vasilev et al. 2009) where the botanical composition of swards and dry mass yield were presented.
During 3 consecutive years for every cut (4 cuts for 2006 and 4 cuts for 2007 and 2008) the content of crude protein (N x 6,25) and crude fibre was determined by Weende methods (AOAC, 1990), phosphorus with hydroquinone, Ca – complexometrically and potassium by flame photometer.
The palatability of the forages of alfalfa, cocksfoot and mixture of alfalfa and cocksfoot was determined by the method of "trough cafeteria" (Gillet et al., 1983). By this method, each animal had a free access to mowed mass from three treatments of forage in equal quantities. Fifteen wethers of the breed of Pleven Blackface sheep at the age of 5 years were used. The mowed green mass was put from each treatment in a quantity of 1 kg for 3 animals. The quantity of the eaten forage was recorded at the end of the first hour from the putting of the forage. The consumed forage from each treatment was presented as % of the total consumed forage from the three treatments and the relative value was given as % of the put quantity.
Statistical analysis of data was made using MS Excel, ANOVA, LSD at P=0.05.

Results and discussion

The content of crude protein and crude fibre in pure swards of alfalfa and cocksfoot, as well as that for the mixture between them are given on Table 1.

Table 1. Content of crude protein and crude fibre in the forage under fertilizing with different potash fertilizers, g/kg DM

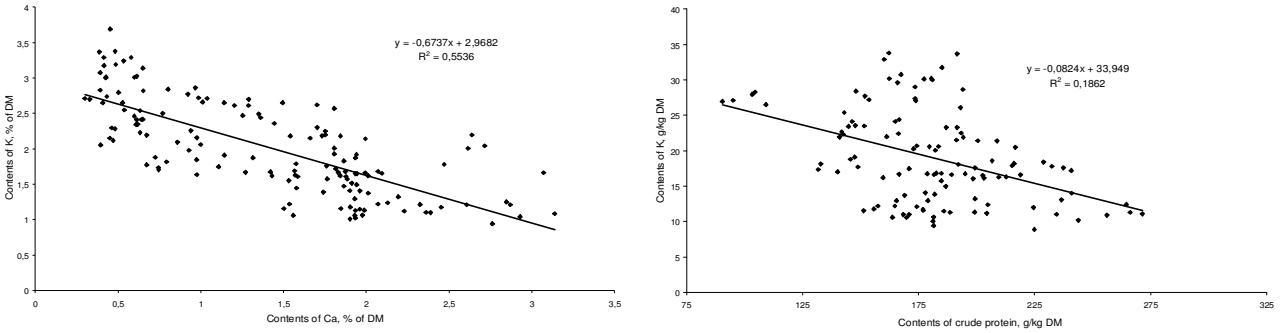
Regrowths / Treatments	1st regrowth		2nd regrowth		3th regrowth		4th regrowth		Average	
	CP	CF	CP	CF	CP	CF	CP	CF	CP	CF
Alfalfa										
N0P0K0	196,1 ± 26,6	214,2 ± 3,4	196,7 ± 15,4	244,4 ± 43,3	206,5 ± 29,2	215,1 ± 35,9	224,9	147.1	206,1 ± 13.4	205,2 ± 41,2
N50P210	198,9 ± 36,7	223,4 ± 20,1	196,8 ± 13,8	256,7 ± 50,2	202,5 ± 33,2	235,2 ± 21,0	243,9	159.1	210,5 ± 22.4	218,6 ± 42,0
NPK-MOP	196,1 ± 35,2	228,4 ± 10,0	194,4 ± 16,6	259,6 ± 63,4	193,5 ± 33,0	222,9 ± 29,4	271,5	132.5	213,9 ± 38.4	210,8 ± 54,6
NPK-KornKali	198,1 ± 39,8	233,7 ± 12,2	196,9 ± 16,3	248,9 ± 44,9	198,2 ± 38,6	232,5 ± 44,0	264,6	133.8	214,5 ± 33.4	212,2 ± 52,8
NPK- MgKainit	202,2 ± 34,5	236,5 ± 16,2	194,8 ± 17,1	252,6 ± 48,1	198,2 ± 38,6	228,0 ± 35,6	266,2	155.1	215,4 ± 34.0	218,0 ± 43,1
x=	198,3 ± 2,5	227,2 ± 8,8	195,9 ± 1,25	252,4 ± 6,0	199,8 ± 4,9	226,7 ± 8,0	254,2 ±19,4	145,3 ± 12,1	LSD 5% 16.7	LSD 5% 12.7
Alfalfa + Cocksfoot										
N0P0K0	163,5 ± 32,3	271,9 ± 17,0	187,0 ± 25,1	257,1 ± 45,6	210,9 ± 54,9	212,5 ± 51,6	256,2	146.1	204.4 ± 39.6	221,9 ± 56,4
N50P210	161,6 ± 28,3	260,1 ± 10,2	191,4 ± 26,3	260,4 ± 38,4	195,2 ± 63,9	239,5 ± 52,5	224,5	176.7	193.2 ± 25.7	234,1 ± 39,5
NPK-MOP	165,8 ± 20,0	266,0 ± 27,0	182,6 ± 17,5	257,4 ± 50,0	192,5 ± 44,0	233,8 ± 54,9	241,0	163.9	195.5 ± 32,3	230,2 ± 46,3
NPK-KornKali	144,7 ± 17,3	270,3 ± 29,0	199,0 ± 40,3	276,4 ± 40,4	192,2 ± 40,5	230,0 ± 37,4	236,6	169.1	193.1 ± 37.7	236,4 ± 49,3
NPK- MgKainit	152,4 ± 9,5	271,6 ± 28,8	190,1 ± 52,4	269,9 ± 19,9	199,1 ± 45,4	219,7 ± 51,8	234,5	165.1	194,0 ± 33,7	231,6 ± 50,4
x=	157,6 ± 8,8	268,0 ± 5,0	190,0 ± 6,0	264,2 ± 8,5	198,0 ± 7,7	227,1 ± 10,9	238,6 ± 11,5	164,2 ± 11,3	LSD 5% 13.1	LSD 5% 13.2
Cocksfoot										
N0P0K0	126,8 ± 43,9	258,3 ± 25,9	141,4 ± 6,3	266,4 ± 19,6	164,4 ± 46,3	230,0 ± 56,3	203,2	179.4	159.0 ± 33,3	233,5 ± 39,3
N50P210	127,0 ± 47,7	257,9 ± 23,9	143,2 ± 2,4	285,0 ± 27,0	171,7 ± 55,1	234,8 ± 53,1	199,3	184.5	160,3 ± 31.9	240,6 ± 42,6
NPK-MOP	120,3 ± 41,5	259,9 ± 28,5	156,3 ± 12,1	273,8 ± 38,6	187,7 ± 59,6	234,2 ± 47,4	212,8	185.0	169.3 ± 40.0	238,2 ± 39,1
NPK-KornKali	122,7 ± 54,0	252,7 ± 28,3	153,8 ± 10,5	262,4 ± 9,4	172,7 ± 46,2	230,1 ± 48,2	198,5	181.5	161.9 ± 31.9	231,7 ± 36,1
NPK- MgKainit	123,8 ± 58,9	266,6 ± 31,4	159,0 ± 10,5	271,8 ± 27,2	186,8 ± 53,6	233,0 ± 50,8	182,6	187.1	163.1 ± 28.9	239,6 ± 39,0
x=	124,1 ± 2,8	259,1 ± 5,0	150,7 ± 8,0	271,9 ± 8,6	176,7 ± 10,1	232,4 ± 2,2	199,3 ± 10,9	183,5 ± 3,0	LSD 5% 13.5	LSD 5% 6.4

As a legume, alfalfa has the highest content of crude protein and the lowest one of crude fibre compared to cocksfoot and the mixture. There were no differences in crude protein content for the three cuts of alfalfa, but for cocksfoot and the mixture there was a tendency to increase of crude protein from first to second, third and fourth cut. This was due to the biological characteristics in species development during the growing season. Cocksfoot formed reproductive stems mainly in first cut and during next cuts it formed vegetative stems and leaves only – aftergrass.

The fourth cut of these three swards (alfalfa, cocksfoot and mixture) was characterized by the highest content of crude protein and the lowest one of crude fibre. This was due to the earlier stage of mowing at the end of growing season. A tendency to lower content of crude fibre was observed in third and especially in fourth cut. This fact was probably due to the more favourable conditions of sward development in autumn. Generative stems dominated in first cut of cocksfoot and after that the sward only consisted of leaves without stems. As a rule, the fibre content in summer cut is higher due to the high summer temperatures that stimulate the accumulation of structural carbohydrates in the plants (Wilson et al., 1991).

Table 2. Potash content in the forage under fertilizing with different potash fertilizers, g/kg DM

	1st regrowth	2nd regrowth	3th regrowth	4th regrowth	Average
			Alfalfa		
N0P0K0	14,65 ± 3,30	12,68 ± 0,40	12,91 ± 3,34	8,91	12,29 ± 2,42
N50P210	15,75 ± 4,91	12,60 ± 1,80	12.03 ± 1,61	10,20	12,65 ± 2,31
NPK-MOP	18,62 ± 5,30	16,28 ± 0,74	13,76 ± 3,35	11,11	14,94 ± 3,24
NPK-KornKali	18,02 ± 5,13	15,80 ± 1,18	14,74 ± 6,17	12,43	15,25 ± 2,32
NPK- MgKainit	15,39 ± 2,94	13,96 ± 3,75	12,20 ± 2,91	11,31	13,22 ± 1,82
x=	16,48 ± 1,73	14,26 ± 1.72	13,13 ± 1,13	10,79 ± 1,32	LSD 5% 1.2
			Alfalfa+cocksfoot		
N0P0K0	22,50 ± 7,27	17,14 ± 1,32	12,38 ± 2,13	10,90	15,73 ± 5,24
N50P210	24,01 ± 4,59	18,77 ± 1,83	14,60 ± 4,11	12,01	17,35 ± 5,24
NPK-MOP	25,07 ± 6,41	18,64 ± 2,74	13,79 ± 1,51	14,01	17,88 ± 5,29
NPK-KornKali	27,63 ± 5,71	18,50 ± 2,49	12,82 ± 2,62	13,07	18,01 ± 6,93
NPK- MgKainit	28,02 ± 5,60	19,90 ± 1,13	14,16 ± 2,84	11,03	18,28 ± 7,46
x=	25,44 ± 2,36	18,59 ± 0,98	13,55 ± 1,33	12,20 ± 1,33	LSD 5% 2.0
			Cocksfoot		
N0P0K0	26,42 ± 4,67	21,29 ± 0,90	17,90 ± 0,79	16,15	20,44 ± 4,52
N50P210	26,00 ± 4,25	22,88 ± 0,80	17,25 ± 1,26	17,60	20,93 ± 4,25
NPK-MOP	27,29 ± 4,05	23,85 ± 0,43	19,71 ± 1,29	16,30	21,73 ± 4,79
NPK-KornKali	27,22 ± 4,41	23,05 ± 1,49	18,40 ± 1,94	16,05	21,18 ± 4,97
NPK- MgKainit	27,11 ± 6,56	22,95 ± 0,75	19,34 ± 2,26	16,85	21,56 ± 4,47
x=	26,81 ± 0,57	22,80 ± 0,93	18,52 ± 1,01	16,59 ± 0,64	LSD 5% 1.1



K / *Ca* *K* / Crude protein

Figure 1. Relationship between contents of K and Ca as well as K and crude protein

It was found from the results of all fertilized and unfertilized variants in alfalfa, cocksfoot and mixture that there was negative relationship between potassium and content of crude protein (r= -0,432) and between potassium and calcium (= - 0,745) (Fig. 1). The increase of potassium content in the plants decreased the crude protein content, which corresponds with the results of Meyer (2006) in alfalfa.

Table 3. Phosphorus and Ca content in the forage under fertilizing with different potash fertilizers, g/kg DM

Regrowths / Treatments	1st regrowth		2nd regrowth		3th regrowth		4th regrowth		Average	
	P	Ca	P	Ca	P	Ca	P	Ca	P	Ca
Alfalfa										
N0P0K0	2,73 ± 0,95	27,68 ± 5,84	2,33 ± 0,59	20,36 ±1,31	3,12 ±1,43	21,80 ± 5,87	2,91	24,14	2,77 ± 0,34	23,50 ± 3,20
N50P210	3,03 ± 1,27	24,73 ± 5,42	2,36 ± 1,42	18,61 ± 1,76	2,88 ± 1,42	21,11 ± 3,27	3,04	20,98	2,83 ± 0,32	21,36 ± 2,52
NPK-MOP	2,87 ± 1,10	24,94 ± 4,44	2,20 ± 1,38	18,06 ± 0,60	3,01 ± 1,38	19,31 ± 1,58	3,77	20,25	2,96 ± 0,64	20,64 ± 3,00
NPK-KornKali	2,55 ± 0,79	23,27 ± 5,80	2,16 ± 0,35	19,22 ± 0,27	3,09 ± 1,34	18,56 ± 1,07	3,41	20,01	2,80 ± 0,56	20,27 ± 2,09
NPK- MgKainit	2,73 ± 0,72	24,25 ± 4,70	2,12 ± 0,59	19,22 ± 0,16	3,43 ± 0,75	19,41 ± 4,30	3,35	19,04	2,91 ± 0,61	20,48 ± 2,52
x=	2,78 ± 0,18	24,97 ± 1,64	2,23 ± 0,10	19,09 ± 0,85	3,11 ± 0,20	20,03 ± 1,35	3,30 ± 0,33	20,88 ± 1,94	LSD 5% 0.4	LSD 5% 1.3
Alfalfa + Cocksfoot										
N0P0K0	2,98 ± 0,77	13,02 ± 3,10	2,42 ± 0,49	15,78 ± 2,09	3,34 ± 1,49	20,98 ± 3,12	3,08	16,95	2,96 ± 0,39	16,68 ± 3,30
N50P210	2,74 ± 0,72	11,96 ± 1,82	2,56 ± 0,33	14,90 ± 5,40	2,89 ± 1,59	17,46 ± 2,20	3,01	13,24	2,80 ± 0,19	14,39 ± 2,37
NPK-MOP	2,68 ± 0,53	10,76 ± 4,83	2,35 ± 0,25	15,82 ± 4,40	2,83 ± 1,30	18,03 ± 2,33	2,90	14,25	2,69 ± 0,24	14,72 ± 3,06
NPK-KornKali	2,71 ± 0,79	7,86 ± 1,99	2,28 ± 0,10	14,63 ± 0,59	2,91 ± 1,50	19,23 ± 3,84	2,73	14,48	2,66 ± 0,27	14,05 ± 4,68
NPK- MgKainit	2,62 ± 0,65	7,81 ± 2,59	2,54 ± 0,46	13,60 ± 3,08	2,83 ± 1,56	18,92 ± 4,05	2,80	13,60	2,70 ± 0,14	13,48 ±4,54
x=	2,75 ± 0,14	10,28 ± 2,37	2,43 ± 0,12	14,95 ± 0,92	2,96 ± 0,21	18,93 ± 1,34	2,90 ± 0,14	14,50 ± 1,45	LSD 5% 0.2	LSD 5% 1,9
Cocksfoot										
N0P0K0	3,20 ± 1,13	4,67 ± 0,38	2,62 ± 0,11	6,37 ± 0,51	3,00 ± 1,53	8,58 ± 1,63	3,17	5,87	3,00 ± 0,27	6,37 ± 1,64
N50P210	2,90 ± 1,20	4,37 ± 0,26	2,60 ± 0,19	6,00 ± 0,11	3,06 ± 1,01	8,58 ± 1,30	3,16	5,22	2,93 ± 0,24	6,04 ± 1,82
NPK-MOP	2,65 ± 1,14	4,22 ± 0,50	2,58 ± 0,32	6,44 ± 0,09	2,73 ± 1,53	8,62 ± 1,94	2,72	4,58	2,67 ± 0,07	5,97 ± 2,02
NPK-KornKali	2,71 ± 1,26	4,02 ± 0,67	2,36 ± 0,14	6,21 ± 0,25	2,66 ± 1,67	8,36 ± 1,29	3,34	4,93	2,77 ± 0,41	5,88 ± 1,88
NPK- MgKainit	2,69 ± 1,04	3,60 ± 0,52	2,68 ± 0,20	6,11 ± 0,11	2,82 ± 2,06	7,65 ± 1,32	2,98	4,96	2,79 ± 0,14	5,58 ±1,72
x=	2,83 ± 0,22	4,18 ± 0,40	2,57 ± 0,12	6,22 ± 0,18	2,85 ± 0,17	8,35 ± 0,41	3,05 ± 0,25	5,11 ±0,48	LSD 5% 0.3	LSD 5% 0.5

There was no significant effect of the potash fertilizing on the content of crude protein in alfalfa and cocksfoot. Irrespective of the fact that the crude protein content was unchanged, the positive effect of the fertilizing was expressed in increased total yield of protein per unit area with increase of dry mass yield, as a result of the fertilizing, as mentioned in our first paper (Vasilev et al. 2009).

Fertilizing with different form of potash fertilizer increased the potash content in alfalfa and cocksfoot, as well as in the mixture between them (Table 2). There was a tendency to decrease of potash content from first to fourth cut. The concentration of potash was the lowest in alfalfa and the highest in cocksfoot and the mixture. This was due probably to the negative correlation between potash content and crude protein (r= -0,432). and between potash and calcium r= - 0,745) (Figure 1.). The content of potassium in cocksfoot and in the mixture was on average 58% and 30% higher respectively compared to alfalfa.

There were higher values of potassium content in the treatments fertilized with potash fertilizers, but with the trend to a slight decrease from first to fourth cut.
Potash fertilizers decreased the content of calcium (Table 3). Calcium was higher in alfalfa, decreased in mixture, and was the lowest in cocksfoot. The negative relationship between the contents of calcium and potassium presented in Figure 1 was confirmed.
Potash fertilizers had no effect on phosphorus content in alfalfa and cocksfoot (Table 3). There was no relationship between potash and phosphorus content.
The relative average results of the forage palatability are given on Table 4. There were no differences in forage palatability in the variants depending on the form of potash fertilizer, but we observed a tendency to increase of palatability (from 3% to 23%) in alfalfa, cocksfoot and the mixture with fertilizing compared to unfertilized variants. The average values of palatability of cocksfoot and alfalfa were close and were probably due to the fact that after the first cut of cocksfoot the next cuts consisted only of leaves that had higher palatability and nutritive value than the stems.

Table 4. Palatability of alfalfa, cocksfoot and mixture between them under fertilizing with different potash fertilizers

Year	Control	NP	NP K (Mop)	NP K (Korn Kali)	NP K (Mg-Kainit)
Alfalfa					
2006	31.4	32.6	31.5	34.7	31.1
2007	57.7	59.5	60.7	64.1	57.3
2008	20,5	20,4	19,5	19,2	20,4
Average	36,5	37,5	37,2	39,3	36,3
Alfalfa + Cocksfoot					
2006	28.9	34.1	32.4	37.4	34.3
2007	57.8	62.7	61.0	67.0	59.8
2008	16,0	20,5	20,4	21,8	21,2
Average	34,2	39,1	37,9	42,1	38,4
Cocksfoot					
2006	35.6	35.4	36.4	34.4	34.8
2007	51.4	54.8	57.7	63.7	47.4
2008	14,1	18,7	22,5	22,5	22,2
Average	33,7	36,3	38,9	40,2	34,8
Average	34,8	37,2	38,8	40,5	36,5

Conclusions

There was no significant effect of fertilizing with Muriate of Potash (MOP)- 60% K2O; Korn-Kali (40% K2O, 6% MgO, 3% Na, 4% S), and Magnesia- Kainit (11% K2O, 5% MgO, 20% Na, 4% S) on the content of crude protein and crude fibre in alfalfa, cocksfoot and the mixture between them. Fertilizing with different forms of potash fertilizer increased the potash content in alfalfa and cocksfoot, as well as in the mixture between them. The concentration of potash was 58% on average higher in cocksfoot compared to alfalfa.
The fourth cut of alfalfa, cocksfoot and the mixture was characterized by the highest content of crude protein and the lowest one of crude fibre.
It was found that there was a negative correlation between potash content and calcium (r= - 0,745), and between potash and crude protein (r= -0,432).
In the variants fertilized with different potash fertilizers there was no statistical influence on the forage palatability, but there was a tendency to increase of palatability in fertilized alfalfa, cocksfoot and mixture compared to unfertilized variants.

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