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CHANGES IN SOME FORAGE INDICATORS OF ANNUAL WINTER CROPS UNDER THE CONDITIONS OF CENTRAL BALKAN MOUNTAINS IN BULGARIA

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Abstract. In this study the highest dry matter yields were harvested from triticale (for pure crops) and from triticale+winter pea (for mixed crops). By pure crops the highest values of crude protein content **(**8.78 and 9.02%) had winter barley and winter vetch, and by mixed crops–winter barley+winter pea, winter barley+winter vetch and triticale+winter pea (11.40, 9.15 and 9.17%, respectively). The content of crude fat in forage had near values for studying pure and mixed crops. For all sowing crops the crude fibre content varied also in comparatively little limits, while the nitrogen–free extract matters for pure crops ranged within widely limits in comparison with mixed crops. The highest crude protein yield from all crops (without the standards) was obtained only by triticale, and it was 40.00% higher than winter barley. All other crops had a lower productivity than other corresponding standards.

Key words: annual winter crops, dry mass, chemical composition, crude protein yield, Central Balkan Mountains (Bulgaria).

Introduction

In Bulgaria a number of studies of the annual winter forage crops have been conducted with regard to the conditions and factors forming their yields [GRAMATIKOV *et al*., 2002; KOLEV *et al*., 2004], as well as estimating nutritive value and quality parameters of the obtained forage [PAVLOV, 1996]. In this connection winter forage pea and the mixed cereal–legume crops are of particular interest [ORAK, 2000; SCHULZ *et al*., 2000; KERTIKOV, 2003].

At present such developments are incomplete and insufficient for the conditions of fore–mountain regions in Bulgaria and have been conducted till now very slightly for the region of the Central Balkan Mountains [LINGORSKI *et al*, 2006; 2010].

The objective of this experiment was to determine the changes of some chemical and bio productive indicators of annual winter cereal and legume pure and mixed crops for green forage production under the conditions of the fore–mountain regions of the Central Balkan Mountains in Bulgaria (Troyan region).

Material and Methods

The experiment covered the period 2003–2005. It was carried out every year in early autumn (in October) in the Experimental field of RIMSA in Troyan on light grey pseudopodzolic soil without irrigation. The block method was used with four replications and harvest plot size of 6m^2.

Agricultural measures were applied according to biophysiological and technological requirements of the respective forage crop. The following species and cultivars of annual winter cereal and legume crops were studied: as pure crops–var. 1–Winter barley cv. Kaskadyor 3 (Standard 1); var. 2–Triticale cv. Rakita; var. 3–Winter pea cv. Mir (No12) (Standard 2); var. 4–Winter vetch cv. Asko 1 and as mixed crops–var. 5–Winter barley+winter pea (Standard 3); var. 6 –Winter barley+winter vetch; var. 7–Triticale + winter pea; var. 8–Triticale+winter vetch.

Sowing was performed at an interrow spacing of 12 cm and a depth of 3–5 cm for barley, triticale and vetch to 5–7 cm for pea with rolling before and after that.

In the experiment the sowing rates followed: winter barley–450 germinable seeds per 1m^2, triticale–450 germinable seeds, winter pea–120 germinable seeds and winter vetch–260 germinable seeds.

The components of the cereal–legume mixed crops were sown in a ratio of 1:3 depending on the sowing rates of pure stands.

Application of phosphorus fertilizer (as double superphosphate) was made once before basic soil cultivation (in September) at 60 active substances (a.s.).

Nitrogen fertilizer (as ammonium nitrate) was applied only once in early spring (in March) during next year, as follows: 80 kg

ha^{-1} a.s. for winter barley and triticale, 50 kg ha^{-1} a.s. for winter pea and winter vetch and 60 kg ha^{-1} a.s. for the mixed crops.

Every year the trial plots were harvested for green forage by cutting them at the following phenological stages: for pure crops–at the hearing of winter barley and triticale and at the flowering of winter pea and winter vetch; for mixed crops–at the early flowering of legume component.

In this research the following characteristics were studied: dry mass and crude protein yields (in t ha^{-1}), the chemical composition (in %) of absolutely dry matter included: content of crude protein (after Kjeldahl), crude fibre (after Heteron and Jensen), crude ash (through dry calcination in a muffle oven at temperature of 550°C), crude fat (after Soxlet), calcium (after Stotz–complexometrically) and phosphorus (by the vanadium–molybdenum method of Gericke and Kurmis).

Samples of chemical analyses were taken at harvesting of the area.

Results and Discussion

The data listed in *Table 1* (for dry mass yields) presents that in 2003 for pure crops there were lower dry mass yield from triticale for cereals and winter pea (Standard 2) compared with the remaining cereals and legumes that were studied. 8.57, 7.16 t ha^{-1} dry mass was obtained by two forage crops respectively.

So, the triticale exceeded standard 1 (winter barley) by 47.50%, while this parameter compared to winter pea was lower for winter vetch–with 54.19%.

For mixed crops (var. 5, 6, 7 and 8) mostly dry mass (9.23 and 9.17t ha^{-1}) were indicated by triticale + winter pea and triticale+winter vetch, respectively.

The obtained plant production was 28.37 and 27.54% according to Standard 3 (winter barley winter pea). For other mixture (winter barley+winter vetch) was established a lower yield–with 34.08%.

Table 1.

Dry mass yields (in t ha^{-1}) of some annual winter cereal and legume pure and mixed crops by years and average for the 2003–2005 period

Variants(pure and mixed crops)	2003		2004		2005		*Average*	
	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
1 (Standard 1)	5.81	100.00	6.59	100.00	6.41	100.00	6.27	100.00
2	8.57	147.50	13.47	204.40	5.08	79.25	9.04	144.18
3 (Standard 2)	7.16	100.00	6.22	100.00	4.04	100.00	5.81	100.00
4	3.28	45.81	2.27	36.49	2.96	73.27	2.84	48.88
5 (Standard 3)	7.19	100.00	8.77	100.00	6.09	100.00	7.35	100.00
6	4.74	65.92	5.79	66.02	5.35	87.85	5.29	71.97
7	9.23	128.37	8.65	98.63	6.76	111.00	8.21	111.70
8	9.17	127.54	5.17	58.95	6.60	108.37	6.98	94.96
LSD at 5%; 9.40%; LSD at 1%; 13.02%; LSD at 0.1%; 18.09%								

In the second year of the study (2004) all pure and mixed crops that were tested had lower yielding capacity in comparison with all three standards with exception of triticale regarding winter barley (Standard 1).

The dry mass obtained from this fodder crop ranged 13.47 t ha^{-1}, i.e. in excess by 104.40%. In the last year (2005) of the experimental period the pure cereal and legume crop standards exceeded the corresponding crops by dry mass productivity–with 20.75% (for Standard 1) and 26.73% (for Standard 2). For two of the mixed crops higher yields than Standard 3 – with 11.00% (for var. 7–triticale+winter pea) and 8.37% (for var. 8–triticale+winter vetch) were obtained, while var. 6 provided 12.15% lower yield. On the whole, for the 2003–2005 period the highest dry mass production for pure crops was harvested from triticale–9.04 t ha^{-1} (with 44.18% higher than to winter barley (Standard 1), while obtained dry mass from winter vetch was with 51.12% lower than Standard 2 (winter pea).

For mixed crops only triticale + winter pea (var. 7) was most productive in comparison to Standard 3 (winter barley + winter pea)–with 11.70%, while the other two

tested crops were lower–yield–with 5.04% (for var. 8) and 28.03% (for var. 6).

The dynamics of some forage biochemical indicators on average for the experimental period (2003–2005) are indicated in *Table 2*.

The obtained data shows that the studied annual winter cereal and legume pure and mixed crops were different values regarding crude protein content. So, considering pure crops, this indicator had the highest values (8.78 and 9.02%) for winter barley and winter vetch, and they exceeded the other two pure crops (triticale and winter pea) with 0.22 and 0.60 percentage points, respectively. The protein content of mixed crops (var. 5, 6, 7 and 8) had relative values but the highest. They were less than 2.25 (var. 6) to 2.48 percentage points (var. 8) in comparison with Standard 3 (11.40%).

Table 2.

Dry mass chemical composition (in %) of annual winter cereal and legume pure crops and mixed crops average for the 2003–2005 period

Variants (pure and mixed crops)	Crude protein, %	Crude fat, %	Crude fibre, %	Nitrogen–free extract matters (NFEM),%	Crude ash,%	Calcium, %	Phosphorus, %	Ca:P
1 (Standard 1)	8.78	2.93	27.78	42.52	7.41	0.870	0.237	3.67
2	8.55	1.98	25.28	50.13	5.50	0.570	0.228	2.50
3 (Standard 2)	8.42	3.23	22.61	50.20	7.77	1.260	0.407	3.09
4	9.02	2.21	23.47	43.60	8.43	1.180	0.314	3.76
5 (Standard 3)	11.40	2.77	23.58	48.66	8.14	0.520	0.303	1.72
6	9.15	1.96	28.72	44.23	7.56	0.790	0.314	2.51
7	9.17	2.30	24.00	49.83	6.30	0.870	0.266	3.27
8	8.92	2.16	28.77	46.67	5.97	0.650	0.303	2.14

The content of crude fat in forage had near values for studying pure and mixed crops. By winter cereals (var. 1 and 2) the crude protein content reached 2.93% and 1.98%, whereas the other crops (legumes–var. 3 and 4) was 3.23 and 2.21%, respectively.

Regard to mixed crops (var.5–8) the difference between the first and the last values according to this indicator were 0.81 percentage points. Maximum crude fat content (2.77%) was established in forage of var. 5–winter barley+winter pea (Standard 3).

Because of the equal harvesting stage of all sowing crops the crude fibre content varied also in comparatively little limits and ranged from 25.28 and 27.78% (for triticale and winter barley) to 22.61–23.47% for winter pea and winter vetch and from 23.58% (var. 5) to 28.77% (var. 8), respectively.

Nitrogen–free extract matters (NFEM) for pure crops ranged within widely limits in comparison with mixed crops.

So, NFEM by cereal crops varied to 42.52–50.13% and by legume crops–to 43.60–50.20%, while for mixed crops this indicator reached from 46.67% (var. 8) to 49.83% (var. 7). Considering crude ash content, the forage crops that were researched had no considerable differences as well. By pure crops more crude ash content was established for winter barley (7.41%) and for winter vetch (8.43%).

By mixed crops more crude ash mixtures with winter barley were accumulated–7.56% (var. 6) and 8.14% (var. 5).

The crude ash for other two mixed crops with triticale (var. 7 and 8) had almost equal, but low values–6.30 and 5.97 percentage points, respectively. As a whole the pure crops had more calcium content in comparison with mixed crops.

So, by pure crops a maximum content was established for legumes (var. 3 and 4)–1.260 and 1.180%, while for cereals (var.1 and 2) it reached 0.870 and 0.570%, respectively. By mixed crops the calcium content in dry mass varied within narrow limits for different variants. So, the highest content of calcium was observed for var. 7–0.870%, while for var. 5 it was indicated least value–0.520%.

Phosphorus content in dry mass of pure and mixed crops did not show significant differences. This indicator varied among 0.228–0.237% for cereals and 0.314–0.407% for legumes and 0.266% (var. 7)–0.314% (var. 6). In general, the correlation values between calcium and phosphorus content had the

biggest values of pure crops, for the experimental period especially by winter barley (3.67) and winter vetch (3.76).

By mixed crops this correlation varied in wide limits–from 1.72 for var. 5 to 3.27 for var. 7. During the first year of the experiment (2003) a maximum crude protein yield per 1 ha (*Table 3*) was obtained from mixed crops (except for var. 6), followed by pure crops.

So, by mixed crops the yields reached 0.82–0.85 t ha^{-1}, while from pure crops it was 0.51–0.73 t ha^{-1} (for cereals) and 0.29–0.60 t ha^{-1} (for legumes).

Only two crops (by one of pure and mixed crops) exceeded the corresponding standards regarding this indicator–the triticale (with 43.14%) and triticale + winter pea (barely with 3.66%).

Table 3.

Crude protein yields (in t ha^{-1}) of some annual winter cereal and legume pure and mixed crops by years and average for the 2003–2005 periods

Variants (pure and mixed crops)	2003		2004		2005		*Average*	
	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
1 (Standard 1)	0.51	100.00	0.58	100.00	0.56	100.00	0.55	100.00
2	0.73	143.14	1.15	198.27	0.43	76.78	0.77	140.00
3 (Standard 2)	0.60	100.00	0.52	100.00	0.34	100.00	0.49	100.00
4	0.29	48.33	0.20	38.46	0.27	79.41	0.25	51.02
5 (Standard 3)	0.82	100.00	1.00	100.00	0.69	100.00	0.84	100.00
6	0.43	52.44	0.53	53.00	0.49	71.01	0.48	57.14
7	0.85	103.66	0.79	149.06	0.62	89.85	0.75	89.28
8	0.82	100.00	0.46	58.23	0.59	85.51	0.62	73.81
LSD at 5%; 9.82%; LSD at 1%; 14.28%; LSD at 0.1%; 21.42%								

In the next year (2004) the biggest exceeding (with 98.27%) of crude protein yields was indicated again by triticale (for pure crops) and triticale+winter pea (with 49.06%). The other crops (winter vetch and mixtures) that were studied had a lower productivity than the standards.

In the last year (2005) of the experiment maximum crude protein productivity was established by three standards in comparison with the other crops.

So, the exceeding of Standard 1 was 23.22%, of Standard 2–20.59% and of Standard 3–from 10.15% (towards var. 7) to 28.99% (towards var. 6).

On average for the 2003–2005 periods the highest crude protein yield from all crops (without the standards) was obtained only by triticale–0.77tha^{-1}, it was with 40.00% higher than winter barley (Standard 1).

All other crops had a lower productivity than the corresponding standards–with 48.92% for winter vetch and from 10.72% (for var. 7) to 42.86% (var. 6).

Conclusion

The comparative study of annual winter cereal and legume pure and mixed crops under the conditions of the Central Balkan Mountains in Bulgaria (Troyan region) showed that average for the 2003–2005 periods the greatest dry mass quantity was obtained from the pure stands of cereal crops. It was higher with 44.18% in triticale, as compared to the winter barley.

In the cereal–legume mixed crops, only the mixture of triticale+winter pea exceeded by 11.70% of barley+winter pea.

By pure crops the highest values of crude protein content (8.78 and 9.02%) had winter barley and winter vetch, and by mixed crops–winter barley+winter pea, winter barley + winter vetch and triticale+winter pea (11.40, 9.15 and 9.17%, respectively).

The content of crude fat in forage had near values for studying pure and mixed crops–from 1.98% for pure crops to 2.77% for mixed crops.

For all sowing crops the crude fibre content varied also in comparatively little limits, while the nitrogen–free extract matters for pure crops ranged within widely limits in comparison with mixed crops.

Considering crude ash content, the forage crops had no considerable differences as well. As a whole the pure crops had more calcium content in comparison with mixed crops.

Phosphorus content in dry mass of pure and mixed crops did not have significant differences.

The correlation values between calcium and phosphorus content had the biggest values of pure crops, especially by winter barley (3.67) and winter vetch (3.76).

By mixed crops this correlation varied in wide limits–from 1.72 to 3.27.

The highest crude protein yield from the all crops (without the standards) was obtained only by triticale, and it was with 40.00% higher than winter barley.

The all other crops had a lower productivity than corresponding standards.

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