Dynamics of some bio–productive parameters of winter RAPESEED MIXTURES FORAGE IN A FOOTHILL REGION IN BULGARIA

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Abstract. During the 2013–2014 period in the Research Institute of Mountain Stockbreeding and Agriculture (RIMSA) in Troyan (Bulgaria) a comparative study of winter rapeseed mixtures for green forage production was carried out. For this purpose were studied mixtures with legume forage crops (wintering field peas and winter vetch) and some cereal species (winter barley and triticale). It has been found that on average for two harvesting seasons (2013–2014 and 2014–2015) a more forage productivity had the winter rapeseed mixtures with legume forage crops. The most active green and dry mass (respectively 2.36 t.ha–1 and 0.39 t.ha–1) was obtained from the mixture with wintering field peas which exceeded the standard crop (winter rapeseed monoculture) respectively with 35.63 and 39.29%. Regardless of the various components, in the winter rapeseed pure and mixed crops the weed infestation was a relatively low, and it had no significant influence of the forage quality.

Keyword: Annual winter mixtures, Rapeseed, Cereal and legume species, Forage indicators.

Introduction

The annual forage plants are more often cultivated as mixed crops. With important application for practice are the winter forage mixtures with cereal or legume species (triticale, wintering field peas, winter vetch etc.) or species from other botanical families (winter rapeseed etc.) [BERKENKAMP and MEERES, 1987; BRAUNWART et al., 2001; MURRAY, 2001; TWIDWELL, 2002; SHPAARA, 2007].

The winter rapeseed (Brassica napus L.) is very valuable annual plant with different applications. The winter rapeseed monoculture is used as an oilseed, biofuel and melliferous culture as well as for green manuring. The winter rapeseed mixtures are used for green animal feeding and for silage preparing.

A lot of studies on winter rapeseed as a forage culture have been conducted abroad. Different aspects of forage bio–productivity [MCCORMIC et al., 2006; SHOAMB, et al., 2014] and basic technological features as fertilization [MASON and BREWAN, 1998; JACKSON, 2002; FATHI et al., 2002; AHMAD et al., 2007; MORADITELAVAT et al., 2008; SIADAT et al., 2011], manuring [CHITALE and BHAMBRI, 2001], farming practices of cultivation [GRANT and BAILEY, 1993; CHRISTEN and SIELING, 1995; JENKINS and LEITCH, 1996; KHAN et al., 2000; OAD et al., 2001; MALHI and GILL, 2004; SHPAARA, 2012] etc. under various soil and climatic conditions in different geographic locations of the world have been studied.

The annual winter mixtures in Bulgaria are sown as a secondary crops after harvesting of early–spring or late–spring mixtures or after different monocultures. For their components are use different plant species comprising the winter mixtures and suitable for cultivation in the relevant region.

Therefore in the recent years in some regions of the country were carried out studies to establish conditions and factors for yield formation and forage quality parameters of some annual winter field crops [PAVLOV, 1996; GRAMATIKOV, 2002; BUTNARIU and SAMFIRA, 2012].

Object of research of a significant part of such publications in Bulgaria were to establish bio–productive characteristics of winter rapeseed hybrids at local growing conditions [DELCHEV, 1988; NIKIFOROV, 2004; IVANOVA and Todorov, 2006; Todorov et al., 2010; IVANOVA, 2012; Todorov, 2012]. In conditions of foothill areas of Central Balkan Mountains in Bulgaria so far is established only suitability and some links of agro–technology of winter annual cereal and legume monocultures and mixtures between them [LINGORSKI and KERTIKOV, 2010; LINGORSKI, 2011; LINGORSKI, 2013]. The absence of
studies with reference to winter rapeseed mixtures under foothill region conditions of Central Balkan Mountains was a prerequisite for this experiment.

The objective of this study was to compare some bio–productive indicators of winter rapeseed mixtures with legume forage crops (wintering field peas, winter vetch) and some cereal species (winter barley, triticale) cultivated for green forage under soil and climatic conditions of typical foothill region (in Troyan area) of Central Balkan Mountains (Bulgaria).

**Material and methods**

Annually the experiment was laid out in experimental field of RIMSA, Troyan in the late summer during two harvesting periods (2013–2014 and 2014–2015). The soil type of the experimental area was light–grey forest (pseudopodzolic) with acidic soil reaction (pH in KCl–5.9) and with low availability of total nitrogen (4.0 mg.kg⁻¹) and phosphorus (1.5 P₂O₅ mg.kg⁻¹) and sufficient availability of potassium (7.2 K₂O mg.100 g⁻¹). The experiment was set up by the block method with 4 replications and size of harvest plots of 5 m². On experimental area were sown a some annual winter mixtures with rapeseed. As variants were studied:

1. Winter rapeseed monoculture as a Standard;
2. Winter rapeseed+Wintering field peas;
3. Winter rapeseed+Winter vetch;
4. Winter rapeseed +Triticale;
5. Winter rapeseed+Winter barley.

The sowing rates of different components of various mixtures were as follows: for Winter rapeseed cv. Rohan–65 germinable seeds m⁻², for Wintering field peas cv. Mir 12–150 germinable seeds m⁻², for Winter vetch cv. Asko 1–260 germinable seeds m⁻², for Triticale cv. Rakita–450 germinable seeds m⁻² and for Winter barley cv. Perun–500 germinable seeds m⁻². The weight ratio of various components in mixtures was 1:1.

Due to unfavorable soil of region (low–productive with heavy loam structure) and weather conditions during autumn–winter period (insufficient rainfall combined with comparative low air temperatures), sowing rates were increased by 20%. According to climatic conditions in late summer, in 2013 sowing was carried out barely on August 27, and in 2014 on August 20. Before sowing necessary kinds of pre–sowing tillage (shallow ploughing, disking, rotary cultivation) were conducted up to obtaining of a garden status of the soil.

The trial plots were rolled after the sowing. The inter–row spacing was 12 cm and the sowing depth was 3–5 cm. The experimental areas of separate variants (crops) were harvested at full flowering of Winter rapeseed in pure crop (var. 1), as well as in mixtures with spring Wintering field peas (var.2), Winter vetch (var.3), Triticale (var. 4) and Winter barley (var.5).

**Note:** Due to the fact that the themes of the Institute are connected mainly with the organic farming, no fertilization is applied in this experiment. Therefore, the productivity of studied crops was mainly related to basic soil and climatic factors (soil availability of basic essential nutrients, including nitrogen, phosphorus and potassium; precipitation and air temperatures).

The different bio–productive indicators of the forage were determined by conventional methods. So for example the values of green and dry mass productivity (in t.ha⁻¹) and weed infestation of crops (in %) was recorded annually. The yielding capacity was determined by cut method with subsequent drying at 105°C of average samples of fresh mass to constant weight and on basis of per cent of dry matter in them it was recalculated per 1 ha. The weed infestation of crops was determined by weight from average fresh samples for each replication and variant, recording separately percent participation of the sown crops and weeds (as a total).

The herbage yield data of green and dry mass productivity was performed using analysis of variance. It were used LSD₀.05 (least significant differences at P<0.05), LSD₀.01 (least significant differences at P<0.01) and LSD₀.001 (least significant differences at P<0.001) regard to green mass and dry matter yields average for 2013–2014 period.
The harvesting of the crops for different variants was done by years as follows: in 2013–2014 harvesting season—on May 16, 2014 and in 2014–2015 harvesting season—on April 24, 2015.

From Tables 1 and 2 is seen that in the 2013–2014 harvesting season despite the small amount precipitation all crops had higher forage yields compared to the next harvesting period (2014–2015).

The reasons for this were the higher air temperatures in the autumn and winter of 2014.

### Results and discussion

<table>
<thead>
<tr>
<th>Harvesting season</th>
<th>Monthly precipitation sum (L.m⁻²)</th>
<th>Rainfall sum for August–May, L.m⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VIII</td>
<td>IX</td>
</tr>
<tr>
<td>2013–2014</td>
<td>12.7</td>
<td>22.7</td>
</tr>
<tr>
<td>2014–2015</td>
<td>8.9</td>
<td>228.5</td>
</tr>
</tbody>
</table>

The obtained data of forage yields by an experimental year and average for the 2013–2014 and 2014–2015 harvesting seasons are shown in Table 3. It is obvious that in first harvesting season, the green and dry mass yields obtained from different mixtures varied from 1.95 t.ha⁻¹ (var. 5—Winter rapeseed + Winter barley) to 2.50 t.ha⁻¹ (var. 2—Winter rapeseed + Wintering field peas) and from 0.33 to 0.42 t.ha⁻¹, respectively.

Regarding productivity of the Standard crop (Winter rapeseed monoculture) the obtained yields were lower in comparison with mixed crops—respectively 1.91 and 0.31 t.ha⁻¹. The exceeding of mixture yields toward Standard was from 2.09% (by var. 5) to 30.89% (by var. 2) for green mass and from 6.45% (by var. 5 and var. 4) to 35.48% as regards the dry matter.

The most productive mixture (Winter rapeseed+Wintering field peas) exceeded the productivity by other mixed crops (var. 3, 4 and 5) with 10.00, 20.80 and 22.00% and respectively with 14.29, 21.43 and 21.43%.

### Table 2

<table>
<thead>
<tr>
<th>Harvesting season</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
<th>XI</th>
<th>XII</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Average monthly air temperatures (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013–2014</td>
<td>26.7</td>
<td>14.2</td>
<td>12.1</td>
<td>7.7</td>
<td>0.8</td>
<td>2.3</td>
<td>4.1</td>
<td>7.4</td>
<td>11.1</td>
<td>16.5</td>
<td>10.3</td>
</tr>
<tr>
<td>2014–2015</td>
<td>19.5</td>
<td>15.4</td>
<td>10.5</td>
<td>5.9</td>
<td>1.7</td>
<td>1.7</td>
<td>1.8</td>
<td>3.3</td>
<td>10.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

In spite of large amount of precipitation during the autumn–winter period of 2014–2015 the green and dry mass yields were less in comparison with those of the previous harvesting season because of the lower air temperatures (Table 1 and Table 2).

Thus, the slow down yields in monoculture crop (var. 1) amounted to 1.22 times at green mass and to 1.29 times in the dry matter. In mixed crops the yields decreased to a lesser degree and were lower from 1.09 times (var. 3) to 1.15 times (var. 5) and respectively from 1.09 times to 1.22 times (Table 3).

In same table is seen that compared with each other, a more productive were mixed crops of winter rapeseed with legumes (var. 2 and 3), as yields exceeded in Standard respectively with 41.67 and 32.05% for green mass and with 50.00 and 37.50% for dry matter.

Note: The values of average monthly air temperatures (°C) and precipitation (L.m⁻²) in August and May of 2013–2015 period indicated in Tables 1 and 2 were calculated according to sowing and harvesting dates of studied crops. Thus, in 2013–2014 harvesting period they were estimated respectively from August 27 to August 31 and from May 1 to May 16. In 2014–2015 harvesting period they were calculated respectively from August 20 to August 31 and from April 1 to April 24.
Green forage and dry mass yields (in t.ha⁻¹ and in %) of winter rapeseed mixtures by years and average for 2013–2014 and 2014–2015 harvesting seasons.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Green mass t.ha⁻¹</td>
<td>Dry matter t.ha⁻¹</td>
<td>Green mass t.ha⁻¹</td>
</tr>
<tr>
<td>1. Winter rapeseed (Standard)</td>
<td>1.91</td>
<td>100.00</td>
<td>0.31</td>
</tr>
<tr>
<td>2. Winter rapeseed+ Wintering field peas</td>
<td>2.50</td>
<td>130.89</td>
<td>0.42</td>
</tr>
<tr>
<td>3. Winter rapeseed+ Winter vetch</td>
<td>2.25</td>
<td>117.80</td>
<td>0.36</td>
</tr>
<tr>
<td>4. Winter rapeseed+ Triticale</td>
<td>1.98</td>
<td>103.66</td>
<td>0.33</td>
</tr>
<tr>
<td>5. Winter rapeseed+ Winter barley</td>
<td>1.95</td>
<td>102.09</td>
<td>0.33</td>
</tr>
<tr>
<td>1. Winter rapeseed (Standard)</td>
<td>1.56</td>
<td>100.00</td>
<td>0.24</td>
</tr>
<tr>
<td>2. Winter rapeseed+ Wintering field peas</td>
<td>2.21</td>
<td>141.67</td>
<td>0.36</td>
</tr>
<tr>
<td>3. Winter rapeseed+ Winter vetch</td>
<td>2.06</td>
<td>132.05</td>
<td>0.33</td>
</tr>
<tr>
<td>4. Winter rapeseed+ Triticale</td>
<td>1.73</td>
<td>110.90</td>
<td>0.28</td>
</tr>
<tr>
<td>5. Winter rapeseed+ Winter barley</td>
<td>1.70</td>
<td>108.97</td>
<td>0.27</td>
</tr>
</tbody>
</table>

LSD₀.₀₅ (16.11%), LSD₀.₀₁ (23.60%), LSD₀.₀₅₀ (35.48%) LSD₀.₀₀₁ (22.91%), LSD₀.₀₁ (28.79%), LSD₀.₀₀₁ (38.23%)

The excess in productivity in of cereal mixed crops (var. 5 and 4) was less and amounted respectively to 8.97 and 10.90% and 12.50 and 16.67%. Average for two harvesting seasons (2013–2014 and 2014–2015) a most plant production was obtained from mixture of Winter rapeseed and Wintering field peas (var. 2)–2.36 t.ha⁻¹ green mass and 0.39 t.ha⁻¹ dry matter which is in over standard crop of Winter rapeseed monoculture respectively with 35.63 and 39.29%.

The second most productive was mixture Winter rapeseed and Winter vetch (var. 3)–2.16 and 0.35 t.ha⁻¹, which exceeded the Standard respectively with 24.14 and 25.00%. The other two mixtures (var. 5 and var. 4) were also more productive than Standard by only with 5.17 and 6.90% for the green mass and with 7.14 and 10.71% for dry matter yields. The performed botanical analysis by two harvesting seasons of experiment is shown in Table 4.


<table>
<thead>
<tr>
<th>Variant (crop)</th>
<th>Winter rapeseed, %</th>
<th>Wintering field peas, %</th>
<th>Winter vetch, %</th>
<th>Triticale, %</th>
<th>Winter barley, %</th>
<th>Weeds %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013–2014 harvesting season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Winter rapeseed (Standard)</td>
<td>95.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5.00</td>
</tr>
<tr>
<td>2. Winter rapeseed+ Wintering field peas</td>
<td>65.70</td>
<td>30.20</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4.10</td>
</tr>
<tr>
<td>3. Winter rapeseed+ Winter vetch</td>
<td>70.90</td>
<td>–</td>
<td>24.60</td>
<td>–</td>
<td>–</td>
<td>4.50</td>
</tr>
<tr>
<td>4. Winter rapeseed+ Triticale</td>
<td>63.60</td>
<td>–</td>
<td>–</td>
<td>28.90</td>
<td>–</td>
<td>7.50</td>
</tr>
<tr>
<td>5. Winter rapeseed+ Winter barley</td>
<td>61.50</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>29.80</td>
<td>8.70</td>
</tr>
<tr>
<td>2014–2015 harvesting season</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Winter rapeseed (Standard)</td>
<td>97.00</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>3.00</td>
</tr>
<tr>
<td>2. Winter rapeseed+ Wintering field peas</td>
<td>75.70</td>
<td>27.20</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.10</td>
</tr>
<tr>
<td>3. Winter rapeseed+ Winter vetch</td>
<td>80.20</td>
<td>–</td>
<td>16.10</td>
<td>–</td>
<td>–</td>
<td>3.70</td>
</tr>
<tr>
<td>4. Winter rapeseed+ Triticale</td>
<td>74.90</td>
<td>–</td>
<td>–</td>
<td>23.80</td>
<td>–</td>
<td>1.30</td>
</tr>
<tr>
<td>5. Winter rapeseed+ Winter barley</td>
<td>82.80</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>16.00</td>
<td>1.20</td>
</tr>
</tbody>
</table>

It is seen that despite different mixtures of Winter rapeseed, the share of their components (wintering field peas, winter vetch, triticale and winter barley) was more than weeds. Thus, in the 2013–2014 harvesting season the Winter rapeseed in mixed crops varied from 61.50% (var. 5) to 70.90% (var. 3), while in the standard crop (var. 1) reached 95.00%. Other components of different mixtures amounted to 30.20% for the wintering field peas (var. 2), 24.60% for winter vetch (var. 3), 28.90% for triticale (var. 4) and 29.80% for winter barley (var. 5). The greatest weed infestation was registered in var. 5 and var. 4–respectively 8.70 and 7.50%, while in other tested mixed crops varied from
4.50% (var. 3) to 4.10% (var. 2). In 2014–2015 harvesting season, Winter rapeseed in mixed crops varied from 74.90% (var. 4) to 82.80% (var. 5), while in monoculture crop amounted to 97.00%.

The constituent cereal and legume components in mixed crops reached 23.80% for triticale (var. 4), 16.00% for the winter barley (var. 5), 27.20% for wintering field peas (var. 2) and 16.10% for winter vetch (var. 3). Least weed infestation (1.20 and 1.30%) has been established in cereals mixed crops (respectively var. 5 and 4); while in experienced remaining crops it ranged from 2.10%(var. 2) to 3.70%(var. 3).

Conclusions
The comparative study of winter rapeseed pure and mixed crops with annual cereal species (triticale and winter barley) and legume forage crops (wintering field peas and winter vetch) in soil and climate conditions of Central Balkan Mountains (Troyan region) carried out. It was determined that a maximum plant production (2.36 t.ha\(^{-1}\) green mass and 0.39 t.ha\(^{-1}\) dry mass) was prepared from the mixture of winter rapeseed and wintering field peas, which is more with 35.63 and 39.29% compared to the winter rapeseed monoculture. In other mixtures the yields excess was less and ranged from 5.17 to 24.14% for green mass and from 7.14 to 25.00% for dry matter.

Regardless of the various components, in rapeseed pure and mixed crops weed infestation was a relatively low, but it had no significant influence on the quality of the obtained forage.

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