

Short Communication

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Agro-ecological study of forage productivity of some annual untraditional drought-resistant fodder species for foothill regions in Central Balkan Mountains (Bulgaria)

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Abstract

Comparative testing of some annual untraditional drought-resistant cereal (foxtail millet and true millet) and legume crops (bitter vetch and chickpea) was conducted during 2011-2013 in the Research Institute of Mountain Stockbreeding and Agriculture (RIMSA) in Troyan (Bulgaria). The largest part of the forage yields had the stems in comparison with leaves and inflorescences. The chickpea had more green mass (12.82 t ha⁻¹) and dry mass (3.27 t ha⁻¹) yields than bitter vetch – respectively by 18.46% and 18.48%. Regarding the cereal crops it turned out that the true millet had more yields (12.98 t ha⁻¹ green mass and 3.32 t ha⁻¹ dry matter) than the foxtail millet (respectively 16.80% and 11.14%). Judging from the factual data it can be considered that the forage species studied in details are suitable for ecological fodder preparation in foothill regions of the Central Balkan Mountains in Bulgaria.

Key words: Cereal, Legume, Drought-resistance, Forage productivity, Yield structure

Introduction

During the last years of global warming plant species have mostly suffered its adverse effects. As a result the average annual temperature variation in recent years is between 11-12°C. The average annual rainfall on the territory of the country decreases to 672 mm and varies considerably per months (Ivanova and Mishev, 2012). This therefore greatly affects the growth and development of field crops (Alexandrov and Hoogenboom, 2000; Alexandrov, 2008).

According to Wilkins and Vidrich (2000) herbage fodder species suitable to grow in dry conditions should be found. Due to the climate changes some researchers focus on examining some cereal and legume pure crops so as to guarantee for their sustainable forage production (Paul et al., 2002).

Testing of different annual species is very

important for animal feeding especially in the summer dry period – June to August (Posler et al., 1993; Gordon and Newmann, 1997).

The current use of annual summer monocultures and mixtures relates to the present climate changes in both regional and global aspect.

Due to the specific soil and climate conditions typical of the foothill regions in the Central Balkan Mountains in Bulgaria and the lack of studies from recent past, the suitability of some annual cereal and legume forage crops was demonstrated in series of studies over the last few years (Lingorski and Kertikov, 2005a; 2005b; Lingorski, 2011a; 2011b; 2012). Their season mixtures were also used for the production of green forage (Lingorski and Kertikov, 2006; 2009; 2010).

The purpose of this study was to establish the parameters for production of ecologic forage mass (without mineral fertilization) from some untraditional cereal (foxtail millet and true millet) and legume crops (bitter vetch and chickpea) for foothill areas of the Central Balkan Mountains in Bulgaria.

Materials and Methods

The experiment was carried out on an area situated at 384 m above sea level in the experimental field of RIMSA, Troyan during 2011–

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2013. The territory of the institute is located in the most Southern parts of the foothill region of the Central Balkan Mountains and belongs to the Northern Balkan climate region of moderate continental climate subzone. During the period of study the average monthly air temperatures during the vegetation period (from March to July) of forage species amounted to 14.7°C (compared to 21-year period – 1988-2008 - 13.8°C, with more than 0.9°C), and rainfall was 401.9 mm (compared to 21-year period – 404.6 mm, i.e. it was less than 2.7 mm). The soil-type of the trial area was light-gray forest (pseudopodzolic) with low native fertility and high acid reaction (Dinkova, 2009).

The soil-cultivating process included the following: ploughing (in autumn of previous year), disk harrowing and cutting (in spring of the corresponding year of sowing). The trial area was pressed by rool pressors once after sowing immediately (annually at the end of April).

The experiment was conducted in four consequent repetitions. The different cereal and legume crops were broadcast sown by hand. All investigation crop variants had by 5 m² harvesting area and they were the following: 1. Bitter vetch (*Vicia ervilia* (L.) Willd. – as a Standard for legumes (var. 1 and var. 2), 2. Chickpea (*Cicer arietinum* L. ssp. *euroasiaticum*), 3. Foxtail millet (*Setaria italica* ssp. *mocharicum* Alef.), 4. True millet (*Panicum miliaceum* L. ssp. *effusum* Al. – with branched panicle) – as a Standard 2 for cereal crops (var. 3 and var. 4).

The experimental area of each variant was harvested for fodder and seeds divided into two equal parts. The studied forage crops were grown under non-irrigated conditions in compliance with the generally accepted standard technologies in Bulgaria (Nikolova and Todorova, 1986; Moskov and Tenova, 2005)

Note: Considering the fact that most of the country's water supply zones are located in the Central Balkan Mountains, annual fertilization was not applied in this experiment.

The annual sowing of the above mentioned crops was carried out in stages, depending on their biological characteristics and climate conditions of the year. The legumes (chickpea and bitter vetch) were first sown because they can grow in colder climate conditions. Because of their thermophylic the sowing of foxtail millet and true millet was done later by permanent of soil temperature 10-12°C. Thus, in 2011 the sowing was done on March 28 for legumes and May 10 for cereals, in 2012 – on March 23 and May 9 and in 2013 - on April 12

and April 23. It can be seen that, depending on the climatic conditions of the year, the sowing dates varied as follows: for legumes – from March 23 to April 12 and for cereals – from April 23 to May 10.

The sowing of the tested forage cultures was accomplished on inter-crop distances 12 cm with values as follows: for bitter vetch - 140 kg ha⁻¹ (300 germinable seeds m⁻²); for chickpea - 100 kg ha⁻¹ (50 germinable seeds m⁻²), for foxtail millet - 15 kg ha⁻¹ (500 germinable seeds m⁻²); for true millet - 25 kg ha⁻¹ (400 germinable seeds m⁻²), and they were in consistence with the purity and germination of seeds. The care for the crops during vegetation period was limited to maintenance of the experimental areas free of weeds.

In the cereals harvesting for green mass was carried out at the beginning of ear formation phase and in legume crops at beans formation phase.

Results and Discussion

Structural elements of the forage yield

Structural elements of the forage yield are included in Table 1 for the different forage crops by years and average for the period of the study. From the table it is seen that in the production of forage the yields are determined by different morphological above-ground plant organs.

Thus, in 2011 for legumes the highest weight had stems - 50.00% for chickpea and 75.00% for bitter vetch. The smallest share (12.50%) of legume crops and inflorescences of bitter vetch had the leaves. As for the cereals, the weight of the stems was more than of leaves and inflorescences (56.25% for foxtail millet and 62.86% for true millet). Due to ear formation phase of harvesting, the inflorescences had the smallest forage proportion (12.50% for foxtail millet and 17.14% for true millet), followed by leaves – 31.25% and 20.00% respectively.

The same table shows that in 2012 the legume stems were the heaviest - 52.63% for chickpea (var. 1) and 39.74% for bitter vetch (var. 2). The leaves again weighed less - respectively 15.38 and 10.53%. The participation of inflorescences (44.89% for chickpea and 36.83% for bitter vetch) is relatively high in the formation of fresh mass yields. Considering the tested cereal crops their stems also exceeded the weight their morphological organs (leaves and inflorescences) - 45.45% and 51.72% respectively. The leaves'percentage from the yield was 36.36% (foxtail millet) and 27.59% (true millet). Due to ear formation phase the inflorescences had the smallest proportion - 18.19% and 20.69% respectively.

Table 1. Structural elements of the yields of forage (in %).

| Variant (forage crop) | Leaves, % | Stems, % | Inflorescences, % |
|---|-----------|----------|-------------------|
| 2011 | | | |
| 1. Bitter vetch (Standard) | 12.50 | 75.00 | 12.50 |
| 2. Chickpea | 12.50 | 50.00 | 37.50 |
| 3. Foxtail millet | 31.25 | 56.25 | 12.50 |
| 4. True millet (Standard 2) | 20.00 | 62.86 | 17.14 |
| 2012 | | | |
| 1. Bitter vetch (Standard) | 10.53 | 39.74 | 36.83 |
| 2. Chickpea | 15.38 | 52.63 | 44.89 |
| 3. Foxtail millet | 36.36 | 45.45 | 18.19 |
| 4. True millet (Standard 2) | 27.59 | 51.72 | 20.69 |
| 2013 | | | |
| 1. Bitter vetch (Standard) | 26.70 | 60.00 | 13.30 |
| 2. Chickpea | 41.50 | 55.30 | 3.20 |
| 3. Foxtail millet | 21.10 | 47.40 | 31.50 |
| 4. True millet (Standard 2) | 19.20 | 57.70 | 23.10 |
| Average for the period 2011-2013 | | | |
| 1. Bitter vetch (Standard) | 16.58 | 58.25 | 20.88 |
| 2. Chickpea | 23.13 | 52.64 | 28.53 |
| 3. Foxtail millet | 29.57 | 49.70 | 20.73 |
| 4. True millet (Standard 2) | 22.26 | 57.43 | 20.31 |

In 2013, the stems of the legumes had biggest proportion in the yields - 55.30% for chickpea and 60.00% for bitter vetch. Inflorescences had a smaller one - 3.30% and 13.30%, respectively. The formation of fresh mass yields reached relatively high values which were 41.50% for chickpea and 26.70% for bitter vetch. The same was valid for the stems whose exceeded that of the other morphological plant organs - 47.40% for foxtail millet and 57.70% for true millet. The inflorescences values that were respectively 31.50% and 23.10% determined the yields. The leaves had the smallest value from the yield (21.10% and 19.20%).

The observational data of this indicator for the experimental period of 2011-2013 shows that the stems (55.45% of legumes and 53.57% of cereals) had the largest proportion, followed by leaves (19.86% of legumes and 25.92% of cereals) and finally the inflorescences (24.71% and 20.52% respectively).

In our previous experiment (Lingorski and Kertikov, 2005b) with comparative testing of some annual spring legume forage crops (vetch, white lupine and bitter vetch) was to establish that the stems participation in the yields forming was from 51.23% to 55.96%. In second place forage yields were determined from the leaves.

It was found similar results in our other experiment (Lingorski and Kertikov, 2005a) but with annual spring cereal forage crops (maize,

sorghum-sudan grass hybrid, sudan grass, oats and true millet). And in these cultures the stems' share in the yield formation was greater than that of the leaves or the inflorescences. Consequently, for maize the proportion was highest – 66.16%, and the lowest one for true millet – 49.05%. The foliar mass percentage was greatest in the yield from sudan grass and sorghum-sudan grass hybrid – respectively 33.65% and 31.80%. The corresponding values for inflorescences were highest for true millet and oats - 23.84% and 19.12%. This confirms the obtained results in the present experiment.

Yield of forage

The forage yield for different crops are shown in Table 2. They included the experimental period 2011-2013.

During the 1st year (2011) the green and dry mass productivity was established by dates and species as follows: on June 28 for bitter vetch (var. 1) and chickpea (var. 2), and on July 7 for foxtail millet (var. 3) and true millet (var. 4).

In 2012 the fodder harvest was done as follows: on June 20 and June 25 for bitter vetch and chickpea and on July 5 - foxtail millet and true millet.

In 2013, the harvest of green mass and dry matter was done on the following dates: on June 30 and July 2 for bitter vetch and chickpea and on June 28 and July 2 - foxtail millet and true millet.

Table 2. Green mass and dry mass yields by years and average for the 2011-2013 period (in t ha⁻¹ and in %).

| Variant (forage crop) | Green mass | | Dry mass | |
|---|--------------------|--------|--------------------|--------|
| | t ha ⁻¹ | % | t ha ⁻¹ | % |
| 2011 | | | | |
| 1. Bitter vetch (Standard) | 15.47 | 100.00 | 4.37 | 100.00 |
| 2. Chickpea | 18.67 | 120.69 | 4.84 | 110.76 |
| 3. Foxtail millet | 12.27 | 88.46 | 3.43 | 112.83 |
| 4. True millet (Standard 2) | 13.87 | 100.00 | 3.04 | 100.00 |
| 2012 | | | | |
| 1. Bitter vetch (Standard) | 9.20 | 100.00 | 2.05 | 100.00 |
| 2. Chickpea | 10.27 | 111.63 | 2.77 | 135.12 |
| 3. Foxtail millet | 7.33 | 84.54 | 1.95 | 74.14 |
| 4. True millet (Standard 2) | 8.67 | 100.00 | 2.63 | 100.00 |
| 2013 | | | | |
| 1. Bitter vetch (Standard) | 7.87 | 100.00 | 1.87 | 100.00 |
| 2. Chickpea | 9.53 | 121.09 | 2.21 | 118.18 |
| 3. Foxtail millet | 12.80 | 78.05 | 3.47 | 80.51 |
| 4. True millet (Standard 2) | 16.40 | 100.00 | 4.31 | 100.00 |
| Average for the period 2011-2013 | | | | |
| 1. Bitter vetch (Standard) | 10.85 | 100.00 | 2.76 | 100.00 |
| 2. Chickpea | 12.82 | 118.16 | 3.27 | 118.48 |
| 3. Foxtail millet | 10.80 | 83.20 | 2.95 | 88.86 |
| 4. True millet (Standard 2) | 12.98 | 100.00 | 3.32 | 100.00 |
| LSD _{0,05} | 705.71 | 74.03 | 210.25 | 95.28 |
| LSD _{0,01} | 1068.65 | 112.10 | 318.38 | 144.28 |
| LSD _{0,1} | 1716.75 | 180.08 | 511.47 | 231.78 |

It can be seen that, depending on the climatic conditions of the year, the harvesting dates varied as follows: in larger limits (12 days) for legumes – from June 20 to July 2 and for a short time (5 days) for cereals – from July 2 to July 7.

From Table 2 it can be seen that in 2011 regarding the legumes (var. 1 and 2) more fresh and dry mass (18.67 and 4.84 t ha⁻¹) was obtained from chickpea compared to bitter vetch (Standard) - by 20.69 and 10.76%. As for cereals (var. 3 and 4) a Standard 2 (true millet) exceeded only fresh mass yields of foxtail millet by 11.54%. Due to the local soil and climate conditions more dry matter was accumulated by foxtail millet during vegetation (3.43 t ha⁻¹). It exceeded the true millet by 12.83%.

The above mentioned table also shows that in 2012, more green mass and dry matter of the legumes (10.27 and 2.77 t ha⁻¹) was obtained by the chickpea compared to bitter vetch (Standard) - respectively by 11.63 and 35.12%. Regarding cereal crops the fresh and dry mass proportion of the true millet exceeded that of the foxtail millet by 15.46% and 25.86%.

In 2013 more fresh and dry mass of the legumes (var. 1 and 2) - 9.53 and 2.21 t ha⁻¹ was obtained by the chickpea compared to bitter vetch (21.09% and 18.18%). As far as cereals (var. 3 and 4) are concerned true millet (Standard 2) exceeded

in the production of forage the foxtail millet respectively by 21.95% for green mass and 19.49% for dry matter.

Considering the whole experimental period by years (2011-2013) it can be concluded that from the legumes the yields of chickpea (12.82 and 3.27 t ha⁻¹) were higher than these of bitter vetch - 18.16% for green mass and 18.48% for dry matter. Regarding the cereal crops the true millet had more yields (12.98 and 3.32 t ha⁻¹) than foxtail millet – in this way more forage was obtained respectively by 16.80 and 11.14%.

In our previous experiment with annual cereal crops (Lingorski and Kertikov, 2005a) highest yields were obtained from sudan grass, followed by sorghum- sudan grass hybrid and true millet. They exceeded the standard (maize) by 37.77%, 29.29% and 21.06% respectively.

In our experiment with some annual legumes (Lingorski and Kertikov, 2005b) highest dry mass yields were obtained from white lupine, followed by horse bean and vetch – more than standard (field pea) with 98.0%, 39.3% and 10.4% respectively.

Conclusions

The comparative agro-ecological study of some annual drought-resistant untraditional forage species for the conditions of foothill areas of the

Central Balkan Mountains (Trojan region) showed the following:

The largest share of the forage yields had the stems, followed by the leaves and inflorescences.

The chickpea had a more yields (12.82 t ha⁻¹ green mass and 3.27 t ha⁻¹ dry matter) compared to bitter vetch - in more respectively by 18.16% and 18.48%. As for the cereal crops the true millet had more yields (12.98 t ha⁻¹ green mass and 3.32 t ha⁻¹ dry matter) than the foxtail millet – more forage mass was obtained respectively by 16.80 and 11.14%.

From the obtained data it can be considered that the studied forage species are suitable for preparation of ecological forage in the foothill regions of the Central Balkan Mountains.

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