*Bulgarian Journal of Agricultural Science, 12 (2006), 447-454*
*National Centre for Agrarian Sciences*

# Study of Forage Productivity and Chemical Composition of Winter Vetch (*Vicia villosa* R.) under Optimization of the Factors of Sowing Time and Rate

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## Abstract

GEORGIEVA, N. and T. KERTIKOV, 2006. Study of forage productivity and chemical composition of winter vetch (*Vicia villosa* R.) under optimization of the factors of sowing time and rate. *Bulg. J. Agric. Sci.,* 12: 447-454

The trial was carried out during the period 2001-2004 by the design of long plot method without irrigation. A number of 9 treatments were formed by mutual combination of factor degrees. Winter vetch variety Asko 1 was used in the study. The stands for forage were harvested at the phenological stage of early flowering. The objective of this study was to investigate forage productivity and chemical composition of winter vetch (*Vicia villosa* R.) under optimization of the factors of sowing time and rate. It was found that the optimal sowing time of winter vetch variety Asko 1 for forage production under the conditions of Central Northern Bulgaria was 20-25 September. The obtained forage yield was mathematically significantly higher than those from the other studied sowing dates. The optimal sowing rate, irrespective of the date, was 220 g.s./m$^2$. The sowing rate exerted a smaller influence on the forage yield, as compared to the sowing time. The content of crude protein, crude fibre and calcium in the vegetative biomass of winter vetch was influenced by the sowing time, but not by the sowing rates differing in size. Similar relationship was not observed in phosphorus content.
*Key words:* winter vetch, sowing time, sowing rates, forage yields, chemical composition

## Introduction

In spite of the excellent qualities of vetch as a forage plant and predecessor, its spread is strongly limited in our country. The changes lately observed in the climate related to global warming and drought renew the interest for wintering forms. One of the great scientifically applicable contributions of our breeding and plant science is the development and introduction of winter vetch biotypes that use autumn-winter moisture in the utmost degree.

In this sense winter vetch of *Vicia villosa* R. species is of interest to agricultural science and practice. The research work on it is limited and some main links of its technology are missing. According to some authors all legumes sown in autumn had greater potential than those sown in spring (Firingioglu et al., 1995). Winter vetch (*V. villosa* R.) gave the highest yield when sown at the earliest date in autumn (Aydin et al., 1996). Teasdale et al. (2004) found that in Vicia villosa a sowing delay of 2-3 weeks decreased the fresh mass yield 20% when harvesting at the flowering to 43% when harvesting before flowering. According to Ozpinar et al. (1996) the optimal sowing rate was 120 kg $ha^{-1}$ for drill sowing and 180 kg $ha^{-1}$ for hand sowing. Voloshin (1993) determined winter vetch as a very plastic crop ensuring high yields of green mass and seeds within a wide range of sowing rate and sowing time and according to the data of Georgieva (1995) and Kertikov (2000) the yield value was influenced more by the sowing time and less by the sowing rate.

The development of contemporary agriculture will rely also in the future on the increase of efficiency of all factors at its disposal as means of directing plant growth, development and productivity (Palazova, 2005). One of the ways of ensuring high productivity and produce quality is the optimization of sowing time and sowing rate.

These circumstances, as well as the development of the new Bulgarian variety Asko 1 of winter vetch, necessitated to carry out research work on some main links of its technology. The objective of this study was to investigate forage productivity and chemical composition of winter vetch (*Vicia villosa* R.) under optimization of the factors of sowing time and rate.

## Materials and Methods

In order to achieve this objective during the period 2001-2004 a field trial was carried out in the second experimental field of the Institute of Forage Crops, Pleven. It was laid out by the design of long plot method with four replications of treatments without irrigation. The harvest plot had a size of 10 $m^2$. A number of 9 treatments were formed by mutual combination of the degrees of A factor - sowing time: $A_1$ - 20-25 September; $A_2$ - 5-10 October; $A_3$ - 20-25 October and B factor - sowing rate: $B_1$ - 180 g.s./$m^2$; $B_2$ - 220 g.s./$m^2$; $B_3$ - 260 g.s./$m^2$. Spring oat was used as a predecessor. After its harvesting a swallow plough was made at a depth of 18-20 cm. The area was cultivated and harrowed before sowing. Phosphorus and potassium fertilizers ($P_6K_4$) were applied before basic soil cultivation and the nitrogenous one ($N_8$), in early spring. The winter vetch variety Asko 1 was used in the study. A small precision seed drill was used at interrow spacing of 11.5 cm and depth of 3-5 cm. Area rolling was always made after sowing. The herbicide Pivot 100 EC (40 ml $da^{-1}$) was used for weed control immediately after sowing. The application was made by a fine-droplet sprayer of SOLO-456 type, with 50 l $da^{-1}$ working solution. The stands for forage were harvested at the phenological stage of early flowering.

The program product STDTA statistically processed all experimental data.

## Results and Discussion

The data in Table 2 shows that during the first year the highest average yield of fresh mass was obtained from the first sowing time (3766.7 kg $da^{-1}$). With prolongation of the sowing time the yield decreased by 7% for the second sowing time and by 19% for the third time of sowing. The dry mass productivity followed the observed relationship in the fresh mass productivity. With prolongation of the sowing time the dry mass yield decreased by 17 and 36% respectively. As the rainfall amount in spring till vetch harvesting at the phenological stage of early flowering was equal for the plants from the three sowing dates - 131.3 mm (Table 1), the rainfall during the autumn-winter period had a crucial role for the high productivity of winter vetch from the first sowing date. It was 70% more than the rainfall for the same period in winter vetch from the second and third sowing date. The opposite trend was observed for the sowing rate factor: with increase of germinable seeds from 180 to 260 g.s./$m^2$ the yield increased. For the first sowing time the yield from the treatment with 260 g.s./$m^2$ was 13% higher as compared to the treatment with 220 g.s./$m^2$ and the difference had very high statistical significance. For the second and third sowing time this difference was considerably smaller - by 1% and 3% respectively and had no mathematical significance. A significant decrease of productivity, when decreasing the sowing rate from 220 to 180 g.s./$m^2$, was recorded for all sowing dates except for the last. It was evident from the result analysis that the maximum dry mass yield for the first sowing time was obtained from the treatment with 260 g.s./$m^2$. With sowing delay to second and third date the highest yield was also recorded for the sowing rate of 260 g.s./$m^2$, but the differences, as compared to the sowing rate of 220 g.s./$m^2$, were not significant. Irrespective of sowing density, the treatments of the first sowing time had the highest productivity followed by the second and third sowing time. The variation in the dry mass yield between the different sowing rates within each sowing date was the greatest for the first sowing time and the smallest for the last. For the study period the lowest yields of fresh

**Table 1**

**Rainfall amount and distribution and drought periods during vegetation**

| Years | Sowing time | Rainfall, mm | | | Droughts | |
|---|---|---|---|---|---|---|
| | | Total | Autumn-winter period | Spring period | Spring-summer period | Duration |
| Year 1 | Time1 | 296.9 | 165.6 | 131.3 | 01.10.2003 | 10 days |
| | Time2 | 228.7 | 97.4 | 131.3 | | |
| | Time3 | 228.3 | 97.0 | 131.3 | 2-15.05 | 14 days |
| Year 2 | Time1 | 406.5 | 311.1 | 95.4 | | |
| | Time2 | 347.2 | 188.8 | 158.4 | 29.04-18.05 | 21 days |
| | Time3 | 349.3 | 181.0 | 168.3 | | |
| Year 3 | | | | | | |
| | Time1 | 346.7 | 243.3 | 103.4 | 12-24.03 | 12 days |
| | Time2 | 319.1 | 198.0 | 121.1 | | |
| | Time3 | 289.9 | 153.9 | 136.0 | 29.03-08.04 | 11 days |

and dry mass were recorded during the second year (Table 2). Due to worse agrometeorological conditions in the sprig of 2003 the winter vetch vegetation was postponed to a later period. Its development coincided with higher average daily temperatures and relatively irregular rainfall distribution. This was the reason to obtain lower results during the second experimental year, which at the harvest time it was found that a part of the plants had become dry at their base. In contrast to the previous year the fresh mass yield for the second (3380.0 kg $da^{-1}$) and third sowing time (2895.5 kg $da^{-1}$) was higher, as compared to the first sowing time (2228.9 kg $da^{-1}$). The data on the dry mass productivity was analogous. For the second and third sowing time it was 45% and 14% higher than that for the first sowing time. Probably this was due to the fact that the long 21-day period of drought for the first sowing time coincided with the most important phenological stages of winter vetch development, budding-early flowering and for the second and third sowing time, with the phenological stages of growth-early budding. According to some authors (Kostov and Hristozov, 1990) vetch is particularly susceptible to drought, namely at the phenological stages of budding and flowering. On the other hand, the rainfall amount in spring till plant harvesting for the first sowing time was about 40-43% lower than that for the second and third sowing time (Table 1). This showed once more the extremely great importance of the rainfall during the period of active

**Table 2**
**Forage yields from winter vetch depending on sowing time and sowingrates by years, kg $da^{-1}$**

| Treatments | | 2001 - 2002 | | 2002 - 2003 | | 2003 - 2004 | |
|---|---|---|---|---|---|---|---|
| Sowing time | Sowing rate, g.s./$m^2$ | Fresh mass | Dry mass | Fresh mass | Dry mass | Fresh mass | Dry mass |
| Time 1 | 180 | 3400.0 | 728.9 | 2093.4 | 450.7 | 6241.8 | 1104.8 |
| | 220 | 3550.0 | 770.7 | 2220.0 | 453.5 | 7000.0 | 1246.0 |
| | 260 | 4350.0 | 871.3 | 2373.4 | 476.1 | 6725.0 | 1183.6 |
| Time 2 | 180 | 3250.0 | 611.0 | 3220.0 | 658.5 | 4916.8 | 860.4 |
| | 220 | 3567.5 | 671.4 | 3413.4 | 680.3 | 5733.3 | 986.1 |
| | 260 | 3675.0 | 675.1 | 3506.6 | 662.8 | 5408.3 | 930.2 |
| Time 3 | 180 | 3050.0 | 503.5 | 2660.0 | 492.1 | 4350.0 | 735.2 |
| | 220 | 3050.0 | 503.5 | 2946.6 | 536.6 | 5116.8 | 864.7 |
| | 260 | 3085.0 | 516.0 | 3080.0 | 548.2 | 4800.0 | 801.6 |
| AxB $GD_{5\%}$ | | 148.10 | 28.33 | 93.07 | 21.69 | 370.99 | 70.68 |
| $GD_{1\%}$ | | 227.47 | 43.43 | 147.48 | 34.62 | 542.56 | 107.39 |
| $GD_{0.1\%}$ | | 380.10 | 72.32 | 258.64 | 61.34 | 833.08 | 176.26 |

vegetation. With regard to the sowing rate there was a trend to increase of dry mass yield at higher sowing rates. An exception from this relationship was observed for the second sowing date where the yield increased till the sowing rate of 220 g.s./m$^2$ and then decreased. When considering the complex interaction of the studied factors and its influence on the yield, it was found that the highest dry mass yield was obtained for the second sowing time and sowing rate of 220 g.s./m$^2$. For the third and first sowing time the productivity was the highest at the sowing rate of 260 g.s./m$^2$. There was a significant difference in the plant productivity from the treatments with 220 and 260 g.s./m$^2$ only for the earliest sowing time and such significance was missing for the next two dates.

For the study period the highest yields of fresh and dry mass were obtained during the third year. Owing to the extremely favorable meteorological conditions, the average fresh mass yield reached the maximum value of 6655.6 kg da$^{-1}$ for the earliest sowing time. Like the trend in the fresh mass productivity during the first year, a decrease of 20 and 29% was recorded for the second and third sowing time, respectively. The dry mass productivity followed the observed relationship in the fresh mass productivity. The highest dry mass yield was formed for the first sowing time and with delay of the sowing time the yield decreased by 21 and 32%, respectively.

In the treatments of sowing rates the treatment with 220 g.s./m$^2$ was the highest-productive for all sowing dates. The lower sowing rate of 180 g.s./m$^2$ led to a yield decrease of 11 and 15%. The higher sowing rate also led to formation of lower yield than that from the optimal treatment (220 g.s./m$^2$) by 5 to 7%. Therefore every declination of the sowing rate from 220 g.s./m$^2$ in the direction of increase or decrease resulted in a lower yield. The negative effect became stronger when delaying the sowing time.

During the considered year maximum dry mass productivity was recorded for the first sowing date and the sowing rate of 220 g.s./m$^2$ followed by the second and third date and the same sowing rate. At all three sowing dates the difference in the productivity of the treatments with 220 and 260 g.s./m$^2$ was not statistically significant.

On average for the study period, the highest fresh mass yield of 4217.1 kg da$^{-1}$ from winter vetch Asko 1 was obtained for the first sowing date, 20-25 September (Table 3). With prolongation of the sowing time the fresh mass yield decreased to 4076.8 kg da$^{-1}$ for the second sowing date and to 3570.9 kg da$^{-1}$ for the third sowing date. The trend in the dry mass productivity was analogous: the highest productivity was recorded for the first sowing time following by a gradual decrease of 8 to 24% for the second and third time. Similar results were obtained by Kuperman (1978). According to the author, for the early sowing dates the plants were distinguished for greater height and productivity and conversely, for the late sowing dates their height and productivity sharply decreased. Kuperman explained this relationship by the different day duration during formation of the plants sown at different sowing dates. Mitrofanov and Rozhkov (1961) also reported in their studies that vetch strongly reacted to day length reduction. The reason for that could be also the different climatic conditions under which the crop developed for the different sowing dates. For instance, on average for the study period the formation of winter vetch for the earliest sowing date

**Table 3**

**Forage yield and chemical composition of winter vetch depending on sowing time and sowing rate on average for the period 2001-2004**

| Treatments | | Fresh mass, kg $da^{-1}$ | Dry mass, kg $da^{-1}$ | Crude protein, g $kg^{-1}$ | Crude fiber, g $kg^{-1}$ | Calcium, g $kg^{-1}$ | Phosphorus, g $kg^{-1}$ |
|---|---|---|---|---|---|---|---|
| Sowing time | Sowing rate, g.s./$m^2$ | | | | | | |
| Time 1 | 180 | 3911.7 | 761.5 | 195.7 | 263.8 | 15.1 | 3.1 |
| | 220 | 4256.7 | 823.4 | 197.1 | 265.9 | 15.1 | 3.1 |
| | 260 | 4482.8 | 843.7 | 198.7 | 260.2 | 16.0 | 3 |
| Time 2 | 180 | 3795.6 | 710.0 | 212.2 | 259.1 | 16.2 | 2.9 |
| | 220 | 4238.1 | 779.3 | 213.7 | 253.7 | 14.3 | 3 |
| | 260 | 4196.6 | 756.0 | 215.3 | 259.2 | 14.6 | 3.3 |
| Time 3 | 180 | 3353.3 | 576.9 | 226.0 | 259.4 | 14.2 | 3.5 |
| | 220 | 3704.5 | 634.9 | 213.5 | 261.3 | 13.7 | 3.1 |
| | 260 | 3655.0 | 621.9 | 210.6 | 257.2 | 14.4 | 3.1 |
| AxB $GD_{5\%}$ | | 186.46 | 34.21 | | | | |
| $GD_{1\%}$ | | 281.27 | 51.68 | | | | |
| $GD_{0.1\%}$ | | 456.18 | 84.01 | | | | |

took place at a temperature sum of 1837.1 °C and rainfall amount of 350 mm (Table 2). With prolongation of the sowing time the temperature sums and rainfall amount decreased, 1610 °C and 298.3 mm for the second sowing time and 1557 °C and 289.2 mm for the third sowing time, respectively. It was evident that the plants from the first sowing date were formed under conditions of better moisture supply which was crucial for their high productivity.

With regard to the sowing rate there was a trend to increase of dry mass quantity till 220 g.s./$m^2$ and then it decreased. An exception from this trend was observed for the first sowing time where the yield increased till the highest sowing rate. The decrease of the sowing density from 220 and 180 g.s./$m^2$ for all sowing dates led to mathematically highly significant difference in the productivity decrease of 8-9%. The variation of the dry mass yield in kg $da^{-1}$ between the different sowing rates within each sowing date was the greatest for the earliest sowing time and gradually decreased for the second and third sowing time.

During the different years, as well as on average for the period 2001-2004 the main factor that, according to the obtained results, exerted a stronger influence on the yield value (3.5 to 15.5%) was the sowing time (Table 4). There was high and very high significance of the differences between the quantities of formed dry mass for the different sowing dates. The sowing rate exerted a smaller influence on the yield value (2.4 to 5.6%) and there was a statistically significant difference only be-

**Table 4**

**Influence of sowing time and rate on dry mass yield from winter vetch on average for the period 2001-2004, kg da$^{-1}$**

| Sowing time | Dry mass | % of average | Sowing rate, g.s./m$^2$ | Dry mass | % of average |
|---|---|---|---|---|---|
| Time 1 | 809.5 | 112.0 | 180.0 | 682.8 | 94.4 |
| Time 2 | 748.4 | 103.5 | 220.0 | 745.9 | 103.2 |
| Time 3 | 611.2 | 84.5 | 260.0 | 740.5 | 102.4 |
| Average | 723.0 | 100.0 | Average | 723.1 | 100.0 |
| **A** GD $_{5\%}$ | 23.95 | | **B** GD $_{5\%}$ | 17.52 | |
| GD $_{1\%}$ | 39.72 | | GD $_{1\%}$ | 24.56 | |
| GD $_{0.1\%}$ | 74.29 | | GD $_{0.1\%}$ | 34.71 | |

tween the treatment with 180 g.s. and the treatments with 220 and 260 g.s.

The crude protein content in the vegetative biomass of winter vetch in the different treatments varied from 196 to 226 g kg$^{-1}$ dry mass (Table 3). The data shows that it was mainly influenced by the sowing time, but not by the sowing rates differing in size. The crude protein content increased by 8.3% and 10% respectively in an ascending gradation from the first to the second and third sowing time. However this increase could hardly exert an influence on the total yield of crude protein, as with prolongation of the sowing time the forage yields decreased. The crude fiber content in the overgrown biomass varied within narrower limits - from 254 to 266 g kg$^{-1}$ dry mass and like the crude protein content it was not influenced by the different sowing rates. There was a slight trend to decrease of the crude fiber content for the second (2.3%) and third (1.6%) sowing date, as compared to the first one. Correlation coefficient between the content of crude protein and crude fiber in the biomass was very pronounced, r = - 0.907. Like the quantitative content of crude protein and crude fiber, the calcium content did not depend on the sowing density. The calcium content was the highest in the plants from the earliest sowing time (15.4 g kg$^{-1}$ dry mass) and decreased in the plants from the second (15.0 g kg$^{-1}$ dry mass) and third (14.1 g kg$^{-1}$ dry mass) sowing time. With regard to the phosphorus content it could be mentioned that it varied within the narrowest limits and pronounced and natural differences could be hardly found depending on the different sowing times and rates. The generalized results show that the content of crude protein, crude fiber and calcium in the vegetative biomass of winter vetch was influenced by the sowing time, but not by the sowing rates differing in size. Similar relationship was not observed for the phosphorus content.

## Conclusions

The optimal sowing time of winter vetch variety Asko 1 for forage production under the conditions of Central Northern Bulgaria was 20-25 September. The obtained forage yield was mathematically significantly higher than those from the other studied sowing dates.

The optimal rate of sowing, irrespective of its date, was 220 g.s./m$^2$. The sowing rate exerted a smaller influence on the forage yield, as compared to the sowing time.

The content of crude protein, crude fiber and calcium in the vegetative biomass of winter vetch was influenced by the sowing time, but not by the sowing rates differing in size. The crude protein content increased by 8.3% and 10% respectively in an ascending gradation from the first to the second and third sowing time. Similar relationship was not observed for the phosphorus content.

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*Received October, 16, 2005; accepted December, 19, 2005.*