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EFFECT OF ROW SPACING ON SEED YIELD OF HAIRY, COMMON AND HUNGARIAN VETCHES

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ABSTRACT

Hairy vetch (*Vicia villosa* Roth), Hungarian vetch (*Vicia pannonica* Crantz) and the winter type of common vetch (*Vicia sativa* L.) were tested for the effect of row spacing (12.5 cm and 50 cm) on yield components and seed yield. The following parameters were analyzed: plant number per unit area, number of branches per plant, number of branches per unit area, crop height, plant length, lodging index, number of pods per plant, number of seeds per pod, 1000 seeds weight and seed yield. The wider row spacing significantly increased crop height, by 13.6%, reduced plant length by 8.5% and increased the lodging index by 22.3%. It also increased the number of branches per plant, the number of pods per plant, the number of seeds per pod, 1000-seed weight and seed yield (by 57.0%, 43.5%, 14.7%, 4.7% and 29.0%, respectively). The highest seed yield was obtained with the Hungarian vetch (1380 kg ha^{-1}) and the lowest with the hairy vetch (784 kg ha^{-1}).

Key words: forage crops, lodging, row spacing, seed yield, stand density, vetches.

INTRODUCTION

The vetch acreage in Serbia ranges from 3000 to 7000 ha (Mikić et al., 2006). Three types of winter vetch are grown commercially. The largest acreage is taken by the winter form of common vetch (*Vicia sativa* L.), followed by the hairy vetch (*Vicia villosa* Roth) and the Hungarian vetch (*Vicia pannonica* Crantz). Domestic cultivars of winter vetch, regardless of plant type, are characterized by a high genetic potential for seed yield (Mihailović et al., 2007b). However, the specific morphological characteristics of the plants bring about extremely high losses in the process of seed production.

Most frequent methods of vetch utilization in Serbia are the production of roughage (green fodder, hay, haylage) and green manure in orchards. The main breeding objectives are thus a maximum yield of the aboveground plant parts, a high proportion of leaves in the total yield, and a thin, soft and easily digestible stem (Mihailović et al., 2007a). Such morphological structure of the plant and the chemical composition of the cell wall and the intercellular space of the mechanical tissue of the stem are associated with significant sensitivity to lodging (Karagić et al., 2008). Since the vetch for forage production is cut from the beginning of flowering to early pod forming, lodging does not pose a significant problem in this case.

By contrast, plant lodging is the most significant problem in winter vetch seed production under the agro-ecological conditions of Serbia (Karagić et al., 2003). The seeding rate used in the winter vetch seed production in our country is quite high, 100 to 120 kg ha^{-1}. This seeding rate has been adopted, for no obvious reason, from the technology of production of fodder vetch (Karagić et al., 2004). The high seeding rate in the forage production is reasonable, because the high stand results in the formation of elongated, thin, delicate and easily digestible stems. In addition, a large number of plants quickly covers the soil (Uzun et al., 2004), which reduces the number of weeds. In seed production, however, such stem characteristics are simply undesirable (Van de Wouw et al., 2003). Such seed crop lodges significantly already at the stage of flowering,

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basal parts of the plant rot, the number of pods is small, seed filling is slow and the yield and quality of seeds are low (Iptas, 2002; Karagić et al., 2008).

Seed producers try to postpone the start of lodging and reduce lodging intensity by growing seed vetch in mixture with small grains as support plants. A large number of authors recommended growing of vetch in mixture with small grains (Iptas, 2002; Karadag and Buyukburc, 2003; Jong, 2006; Lauk and Lauk, 2006), while Andrzejewska et al. (2006) claims that the vetch growing in mixture with small grains is the only effective way to prevent vetch lodging.

However, growing vetch/small grain mixture imposes a number of technical and organizational constraints in the production of seed. Control of grassy weeds is completely excluded (Karagić et al., 2008), and the companion crops do not mature simultaneously (Iptas, 2002; Karagić et al., 2008). This growing method imposes additional problems to seed processing and, additionally, the seed yield of companion-cropped vetch is often lower than that of single-cropped vetch (Nikolaev and Kozmin, 1973). Finally, the domestic seed production legislation does not recognize the term "support crop", i.e., small grains in a vetch crop are treated as alien plant species, which may be a reason for the seed crop to be rejected.

Reduction of seeding rate and increase of row distance should produce a thinner stand and reduce plant sensitivity to lodging, resulting in increased seed yield. The objective of this investigation was to determine the effect of planting methods on the intensity of lodging, yield components and grain yield of winter vetch grown as a single crop.

MATERIAL AND METHODS

Experiments were conducted at Rimski Šančevi experiment field of Institute of Field and Vegetable Crops, Novi Sad during 2007/2008 and 2008/2009 growing seasons.

A two-factorial trial was established in a modified block system, with random arrangement of experimental plots, in three replications. The first factor, plant species, included three treatments: the winter form of the common vetch (*Vicia sativa* L.) (cv. Neoplanta), the hairy vetch (*Vicia villosa* Roth), (cv. NS Viloza) and the Hungarian vetch (*Vicia pannonica* Crantz) (cv. Panonka). All three cultivars had been developed at Institute of Field and Vegetable Crops. The second factor was the planting method, which included two variants: narrow-row planting at 12.5 cm and wide-row planting at 50 cm.

Winter barley was the previous crop to vetch. After barley harvest, crop residues were shredded and the stubble was harrowed under, at the depth of 15 cm. Fertilization was performed before primary tillage, applying 250 kg ha^{-1} of NPK 15:15:15. The primary tillage was conducted in mid-September, at the depth of 20-25 cm. Seedbed preparation was performed at the depth of 8-10 cm. The planting was performed on 10 October 2007 and 8 October 2008, using planting machines Amazone and Nodet, with the former for the narrow- and the latter for the wide-row planting. The seed rates were 80 kg ha^{-1} for the narrow- and 17 kg ha^{-1} for the wide-row planting. After planting, the experimental plot was smooth rolled and an herbicide treatment was applied, using Prometryn in the dose of 2.0 l ha^{-1}.

The experimental unit size was 8.5 m^2 for the narrow-row planting (2.125 x 4 m), with seventeen rows per plot, and 10 m^2 for the wide-row planting (2.5 x 4 m), with five rows per plot. Path width between the plots was 50 cm.

Weed control during growing season was performed with imazethapyr (preparation: Pivot) applied in the dose of 0.3 l/ha at the early stage of intensive growth. In addition, two inter-row cultivations were performed in the wide-row variant. Crop protection from harmful insects was performed at the stage of budding and the end of flowering, applying chlorpyrifos and cypermethrin (preparation: Nurell D) in the dose of 1.0 l ha^{-1}.

In the course of 2008 and 2009, the following parameters were identified and analyzed in the winter vetch crop:

a) seed yield components: number of plants per unit area, number of branches per plant, number of branches per unit area, number of pods per plant, number of seeds per pod, 1000-seed weight;

b) other agronomical important characteristics: crop height, plant length, lodging index;

c) seed yield of winter vetch.

The analysis of seed yield components and other characteristics were carried out on plants from inner rows that covered an area of 1.0 m^2. The number of plants per unit area was determined by counting plants in the spring. All other analyses were performed at the stage of seed physiological maturity, immediately before crop desiccation.

Vetch harvesting was done with a Hege combine, from 1 to 15 July 2008 and 3 to 15 July 2009, after crop desiccation. The desiccation was performed with diquate (preparation: Reglone) in a dose of 4 l ha^{-1}, when about 80% of pods were mature. After harvest, the seed was processed and vetch seed yield level was determined by measuring the weight of pure, processed seed from individual experimental units.

The results were statistically processed by the analysis of variance, and significance of differences was assessed by the least significant difference (LSD) test. Statistical software MSTAT was used.

RESULTS AND DISCUSSION

The average number of plants per unit area was 80.4 (Table 1). The number of plants in the narrow-row variant was 117.7, which was highly significant in comparison with the wide-row variant, in which it amounted to 43.1. The amount of seed for vetch sowing in narrow rows was 3.7 times that used in wide-row planting, while the obtained number of plants per unit area was increased by 1.73 times. Seymour et al. (2002) found the optimal stand density for vetch seed production to be 40 plants/m^2.

Table 1. Number of plants, number of stems per plant and total number of stems depending on vetch species and row spacing (average 2008-2009)

Vetch species	Row spacing cm	No. of plants per m^2	No. of stems per plant	No. of stems per m^2
V. villosa Roth	12.5	117.3	3.2	375.36
	50	40.7	4.6	187.22
	Average	79.0	3.9	281.30
V. sativa L.	12.5	129.0	2.8	361.20
	50	49.8	4.7	234.06
	Average	89.4	3.8	297.60
V. pannonica Crantz	12.5	106.7	3.0	320.10
	50	38.7	4.7	181.89
	Average	72.7	3.9	251.00
Species average	12.5	117.7	3.0	352.20
	50	43.1	4.7	201.10
	Average	80.4	3.8	276.60

LSD	Vetch species		Row spacing		Interaction	
	5%	1%	5%	1%	5%	1%
No. of plants per m^2	12.25	17.43	10.00	14.23	17.33	26.64
No. of stems per plant	0.394	0.561	0.322	0.458	0.557	0.793
No. of stems per m^2	29.24	41.59	23.87	33.96	41.35	58.82

The largest number of plants, 89.4 plants/m^2, was achieved with the common vetch, the lowest, 72.7 plants/m^2, with the Hungarian vetch. This difference was not significant. The average number of branches per plant was 3.8. The increased row spacing positively affected the branching.

The average number of branches in the wide-row variant was 4.7, which was 57.0% more compared with the narrow-row variant, in which the number of branches per plant was 3.0. Branching intensity did not differ significantly among the tested plant species.

Stand density is determined by the total number of branches per unit area, which averaged 276.6 in our study. Stand density in the narrow-row variant was 352.2 branches/m^2, which was 75.0% higher as compared to the value obtained in the wide-row variant. Intensive branching in the wide-row variant significantly reduced the difference in stand density. The difference in the number of plants per unit area in the spring was 173%, and in the number of branches per unit area before harvest was 75%.

The highest stand density was achieved with the common vetch, 297.6 branches/m^2, and the lowest with the Hungarian vetch, 251.0 branches/m^2. The difference was highly significant. The density in the case of the hairy vetch was 281.3 branches/m^2, which was significantly higher compared with the Hungarian vetch. The difference in stand density between the common vetch and hairy vetch was not significant.

The crop height, on average for the experiment, was 25.1 cm (Table 2). Crop height in the case of wide-row planting was 26.7 cm, significantly higher compared with 23.5 cm obtained with the narrow-row planting. Tallest crops were found for the Hungarian and hairy vetches, 30.1 cm and 29.2 cm, respectively. The difference between these values was not significant. The crop height of the common vetch was 16.2 cm, highly significantly lower than the heights of the former two species.

Table 2. Crop height, plant length, and lodging index depending on vetch species and row spacing (average 2008-2009)

Vetch species	Row spacing cm	Crop height cm		Plant length cm		Lodging index	
V. villosa Roth	12.5	27.4		173.7		0.160	
	50	30.9		156.4		0.197	
	Average	29.2		165.1		0.179	
V. sativa L.	12.5	16.4		117.7		0.141	
	50	15.9		110.9		0.143	
	Average	16.2		114.3		0.142	
V. pannonica Crantz	12.5	26.8		106.9		0.251	
	50	33.4		99.8		0.335	
	Average	30.1		103.4		0.293	
Species average	12.5	23.5		132.8		0.184	
	50	26.7		122.4		0.225	
	Average	25.1		127.6		0.205	
LSD		Vetch species		Row spacing		Interaction	
		5%	1%	5%	1%	5%	1%
Crop height		3.890	5.533	3.176	4.518	5.501	7.825
Plant length		11.95	17.00	9.76	13.88	16.90	24.05
Lodging index		0.039	0.055	0.032	0.045	0.055	0.078

As vetch plants are prone to lodging, it is our view that it is not possible to measure plant height, but only plant length. The average plant length was 127.6 cm. The Hungarian vetch was shortest, 103.4 cm, the hairy vetch was longest, 165.1 cm, and the common vetch was intermediate, 114.3 cm. The hairy vetch cultivar had a highly significant length of plants in comparison with the other two cultivars. The difference between the common and the Hungarian vetch cultivars, although it was 10.9 cm, was not significant. The average length of plants in the narrow-row variant was 132.8 cm. In the wide-row variant, it was 122.4 cm. Under conditions of narrow planting, Mihailović et al. (2007a) found that the plant length of four common vetch cultivars ranged from 86 to 112 cm. Plant length is significantly affected by environmental conditions. In the period 2002-2005, the average height of common vetch, hairy vetch and Hungarian vetch plants was

88 cm, 98 cm and 79 cm, respectively (Mihailović et al., 2007b). Uzun et al. (2004) found no significant differences in plant length of the Hungarian vetch planted with different seeding rates. Orak and Nizam (2004) reported that the plant length of the common vetch varied from 62.90 cm to 92.30 cm in dependence of the genotype.

Plant lodging can be quantified as the index of lodging, which is a ratio between crop height in the field and the real plant length. The lodging index has a range of values between 0 and 1. As the lodging rate intensifies, the index becomes smaller, moving towards zero. An absolutely upright crop would have the lodging index of 1. In our case, the lodging rate was high and the average lodging index before harvest was quite low, amounting to 0.205. The lowest lodging rate was observed in the Hungarian vetch cultivar, which had the highest lodging index, 0.293. The hairy vetch and the common vetch cultivars had significantly lower lodging indexes, 0.179 and 0.142, respectively. The lodging index in the narrow-row variant was 0.184 and it was significantly lower than that in the wide-row variant (0.225). The absolutely highest lodging index was found for the Hungarian vetch cultivar in the wide-row variant (0.335). The lowest lodging index was found for the common vetch cultivar in the narrow-row variant (0.141). Van de Wouw et al. (2003) found that at the stage of 50% flowering, the common vetch and five related species varied in the lodging index from 0.1 to 1.0, or 0.57 on average.

The average number of pods per plant was 31.6 (Table 3). The number of pods per plant recorded in the wide-row variant (37.3) was significantly higher compared with the number of pods in the narrow-row variant (26.0). The hairy vetch cultivar had the largest number of pods per plant, 40.9, while the common vetch had smallest number of pods, 21.2.

Table 3. Number of pods per plant, number of seeds per pod, 1000-seed weight and seed yield depending on vetch species and row spacing (average 2008-2009)

Vetch species	Row spacing cm	Number of pods per plant	Number of seeds per pod	1000 seed weight g	Seed yield kg ha^{-1}
V. villosa Roth	12.5	33.4	3.14	29.12	650
	50	48.4	3.61	32.61	917
	Average	40.9	3.38	30.87	784
V. sativa L.	12.5	17.2	4.69	44.82	903
	50	25.2	5.50	45.21	1072
	Average	21.2	5.10	45.02	988
V. pannonica Crantz.	12.5	27.4	3.79	38.56	1199
	50	38.3	4.22	40.03	1560
	Average	32.9	4.01	39.30	1380
Species Average	12.5	26.0	3.87	37.50	917
	50	37.3	4.44	39.28	1183
	Average	31.6	4.16	38.39	1050

LSD	Vetch species		Row spacing		Interaction	
	5%	1%	5%	1%	5%	1%
Number of pods per plant	2.804	3.988	2.289	3.256	3.965	5.640
Number of seeds per pod	0.407	0.578	0.332	0.472	0.575	0.818
1000 seed weight (g)	1.300	1.849	1.062	1.510	1.839	2.615
Seed yield	45.89	65.28	34.47	53.30	64.90	92.31

In our study, the number of pods per plant in the Hungarian vetch cultivar was 32.9 on average for the experiment. All differences in the number of pods per plant were highly significant.

Mihailović et al. (2007b) found the largest number of pods per plant in the common vetch (39.5), somewhat lower in the Hungarian vetch (35.8) and the lowest in the hairy vetch (20.3). In a study of Orak and

Nizam (2004), the number of pods per plant in the common vetch varied from 7.45 to 18.75, depending on the genotype. All differences in the number of pods per plant were highly significant. Conversely, Uzun et al. (2004) found no significant differences in the number of pods per plant in the Hungarian vetch. Using the seeding rates from 20 to 160 kg ha^{-1}, they obtained 30.1 to 34.1 pods per plant.

The average number of seeds per pod was 4.16 in our study. The number of seeds per pod in the wide-row variant was 4.44, which was significantly higher than the number obtained in the narrow-row variant (3.87). The largest number of seeds was found in the pods of the common vetch cultivar (5.10), and lowest in the pods of the hairy vetch cultivar (3.38), while the number of seeds in the Hungarian vetch cultivar was 4.01. All differences in the number of seeds per pod among the studied species were highly significant. Iptas (2002) found the average number of seeds per pod of 4.84 in a pure crop of the Hungarian vetch. In the study of Orak and Nizam (2004), the number of seeds per pod of the common vetch varied from 5.25 to 6.20, depending on the genotype.

The average 1000-seed weight was 38.39 g. The seeds produced in the wide-row variant (39.28 g) was significantly larger compared with the seeds from the narrow-row variant (37.50 g). The largest 1000-seed weight of 45.02 g was found in the common vetch cultivar, the Hungarian vetch cultivar had the weight of 39.30 g, and the lowest weight was in the hairy vetch cultivar, 30.87 g. All differences in the 1000-seed weight among the three types of vetch were highly significant. The largest difference in the 1000-seed weight due to row spacing was found in the hairy vetch. The weight of the seed produced in the wide-row variant (32.61 g) was significantly higher compared with that produced in the narrow-row variant (29.12 g). The results obtained for the 1000-seed weight are in agreement with the values reported by Mihailović et al. (2007b) for the common vetch, Hungarian vetch and hairy vetch (46.3 g, 39.5 g and 31.8 g, respectively). In contrast to our results, Çakmakci and Açikgoz (1994) found a positive correlation between the 1000-seed weight and seed yield of the common vetch. Iptas (2002) found significant differences in 1000-seed weight of the Hungarian vetch depending on row spacing.

On average for the experiment, the vetch seed yield was 1050 kg ha^{-1}. The yields in the wide- and narrow-row variants were 1183 kg ha^{-1} and 917 kg ha^{-1}, respectively. The effect of planting method on seed yield was highly significant - the wide-row planting brought an increase in the vetch seed yield of 29.0%. In a study of Iptas (2002), the increase of row width from 17.5 cm to 35.0 cm increased the yield of the Hungarian vetch from 881 kg ha^{-1} to 1248 kg ha^{-1}. Martiniello and Ciola (1993) too found that wider row spacing increased the seed yield of hairy vetch. Conversely, Uzun et al. (2004), studying the effect of seeding rate of the seed yield of Hungarian vetch, obtained highest yields of 1403 kg ha^{-1} and 1398 kg ha^{-1} with the seeding rates of 160 kg ha^{-1} and 80 kg ha^{-1} of seed, respectively, in the row spacing of 17.5 cm. Also, Aydogdu and Açikgoz (1995) achieved highest seed yields of the common vetch with the highest seeding rates tested, 250 and 300 seeds/m^2, as well as a significant positive correlation between seed yield and forage yield. On the other hand, El Moneim (1993) found a negative correlation between seed yield and forage yield of hairy vetch. The differences between the results of our study and the results of the authors quoted above stress the importance of agro-ecological conditions in the production of winter vetch seed.

In our study, the highest yield was achieved with the Hungarian vetch cultivar and the lowest with the hairy vetch cultivar, 1380 kg ha^{-1} and 784 kg ha^{-1}, respectively. The seed yield of the common vetch cultivar averaged 988 kg ha^{-1}, which was 26.0% more compared with the hairy vetch cultivar and 39.7% less compared with the Hungarian vetch cultivar.

The absolutely highest yield was obtained with wide-row planting of the Hungarian vetch cultivar, 1560 kg ha^{-1}, the absolute lowest yield with the narrow-row planting of the hairy vetch cultivar, 650 kg ha^{-1}. The obtained yields in seed yield were in good agreement with the results of Mihailović et al.

(2004). Comparing the common and hairy vetches, Siddique and Loss (1996) concluded that the common vetch, with an average seed yield of 1.6 t ha^{-1}, has a significantly higher production potential than the hairy vetch. In a study of Orak and Nizam (2004), the seed yield of the common vetch varied from 908 to 2785 kg ha^{-1} depending on the genotype. Mihailović et al. (2007b) obtained the seed yields of the common, Hungarian and hairy vetches which amounted to 1130 kg ha^{-1}, 925 kg ha^{-1} and 770 kg ha^{-1}, respectively. The difference between these two annual seed yields in hairy vetch cannot be attributed exclusively to differences in lodging. It is quite probable that the hairy vetch had significantly higher rates of pod breaking and seed shattering before harvest (Lloveras et al., 2004).

CONCLUSIONS

On the basis of the obtained results, the following conclusions could be drawn:

The wide-row spacing significantly affected the height of plants, increasing it by 13.6%, the number of branches per plant, by 57.0%, the number of pods per plant, by 43.5%, the number of seeds per pod, by 14.7%, and the 1000-seed weight, by 4.7%. It reduced the length of plants, by 8.5%, and the rate of lodging, by 22.3%.

The planting in wide rows positively affected the yield of vetch seed. The yield increase compared with the planting in narrow rows amounted to 29.0%.

The Hungarian vetch showed the highest seed yield potential. Compared with the common and the hairy vetches, the achieved yield was higher by 39.7% and 76.0%, respectively.

The effect of wide rows on seed yield increase was different, depending on vetch type. The highest yield increase was registered in the hairy vetch (41.0%), followed by the Hungarian vetch (30.1%), and the common vetch (18.7%).

In brief, planting three vetch species in narrow and wide rows has different impact upon both seed yield components and seed yield in each. It is hairy vetch that responses most favourably to wide-row planting. Hungarian vetch surely deserves more thorough study of its yield components in order to fulfil its high seed yield potential, while common vetch needs carefully selected and conducted agronomic measures to produce high seed yields.

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